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for the drilling-producing-pipe line industry

PETROLEUM REFINER and The REFINERY CATALOG
for the refining-natural gasoline industry

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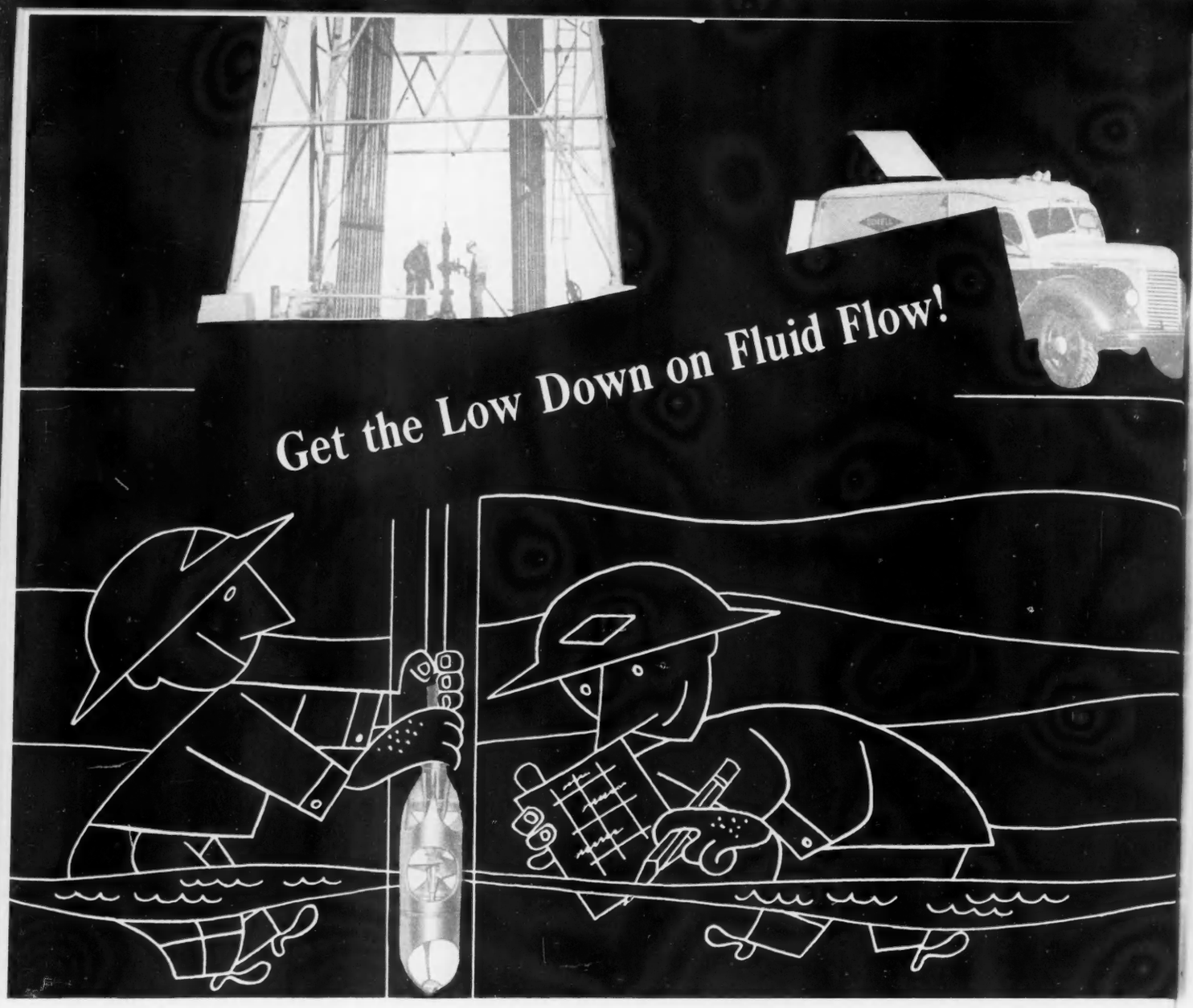

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FOR OIL INDUSTRY CHEMICAL SERVIC

CRUDE OIL SITUATION

APPARENTLY THE oil industry has been doing somewhat better than a good job! Prospects of heavy demand for crude oil and refined products during the past two years have resulted in very heavy increases of production, and even in the face of record demand, added to proven reserves. Last summer, fearful of another bad winter, the oil industry engaged in a campaign of caution against the purchase of oil burners. This campaign apparently was ultra successful, even to the point of causing some heavy industrial users of fuel oil to change back to coal.

THEN CAME the mildest early winter and late fall that we have known in a long time. Came also maritime strikes on the East and West Coasts which drastically reduced fuel oil consumption during the time they lasted. Result—stocks of crude oil and of refined products are piling up to the point where some more fairly heavy cutbacks in production probably may be expected.

H. B. FELL, executive vice president of the Independent Petroleum Association of America, in a statement released about the middle of January started off this way:

"AS THE new year 1949 begins, we find petroleum and petroleum products in oversupply." The executive of a major oil company told the publisher of WORLD OIL: "The oil situation has changed a helluvalot during the past six weeks. Not even the Bureau of Mines forecast of an increase of 6 percent in consumption during the first quarter of 1949 will be enough to take care of the situation. I look for a slowdown in refinery operations during the next month. The mild winter, the maritime strikes, both have contributed to the present heavy stocks. Our company has had to run 3 million barrels of refined products into storage intended for crude oil."

THEN, IN answer to the direct question, he said, "No, I do not look for a price cut in crude."

STILL ANOTHER company executive put it this way: "The industry's statistical position has been completely reversed during the last quarter of 1948. There now is an oversupply in contrast with the previous shortage. This is evidenced by the fact that too much oil went to storage during the last part of 1948. Stocks of crude oil and principal refined products (gasoline, kerosine, distillate fuel oil and residual fuel oil) increased a total of 47 million barrels during the last three months of 1948, or an average of 510,000 barrels dailly. As a result, year-end stocks of crude and principal refined products were 105 million barrels greater than a year previous."

MR. FELL, already quoted, touches on imports in his statement. "Imports for the year 1948 averaged approximately 500,000 barrels per day, which is an increase of nearly 15 percent over 1947," he says, adding that imports ran in excess of 550,000 barrels per day during the last quarter.

HE COMMENTS on the estimate of the U. S. Bureau of Mines that "consumption will be up 6 percent during the first quarter of 1949 over that quarter in 1948," saying that he thinks it will prove conservative. But on the other hand he offers the opinion that the Bureau of Mines estimate on probable imports will be low. Naturally, because it follows the long line policy of his association, he holds to the theory that imports should be cut.

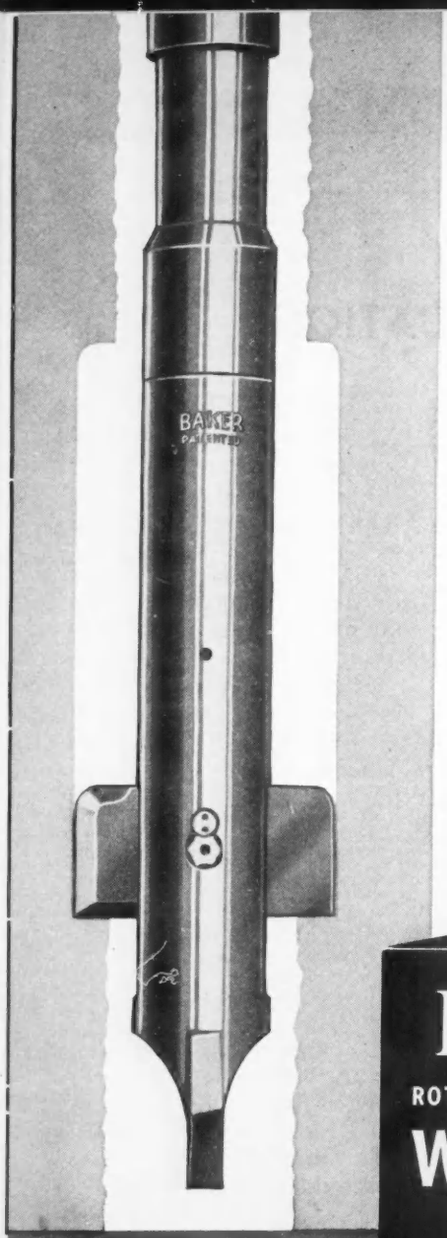
STILL ANOTHER major company executive contacted was of the opinion that a cutback in production would be necessary. He said that one customer who has been taking a sizable quantity of crude oil from his company had called within the past few days and asked for suspension of all crude oil deliveries on the ground that all storage was full and the customer could not handle additional shipments.

HE, TOO, felt that while the crude market was soft, there is no likelihood of a price cut for some time, if then. This, providing production is kept in line.

SUMMING UP the situation as it appears to us, we are faced with a temporary surplus of crude and refined products. Whether or not this surplus becomes more serious depends upon consumption (which appears headed upward) and close attention to market needs, and market prospects.

WITHIN THE past year or two we have heard much as to whether or not the m.e.r. is being exceeded in some areas in the anxiety to get out the oil. Frankly, we do not know where the m.e.r. is being exceeded, if anywhere, and we realize that two different organizations would likely have different ideas as to what the m.e.r. actually is. We think that it is unlikely that imports will increase and that there is a probability that they may be held to a half million barrels a day.

FROM VENEZUELA we hear word of probable cutbacks in drilling and production. This would seem to confirm our idea that imports will be kept in line.



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MANY IMPORTANT USES

THE BAKER ROTARY WALL SCRAPER is extremely versatile and is successfully and economically used for many worthwhile applications, a few of which are shown below. It will pay you to learn all about the Baker Rotary Wall Scraper (Product No. 500-D) from your BAKER (or Composite) CATALOG, or better yet, ask the Baker representative in your area for helpful suggestions as to how this efficient tool will fit right into your drilling program.

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ROTARY HYDRAULIC EXPANSION

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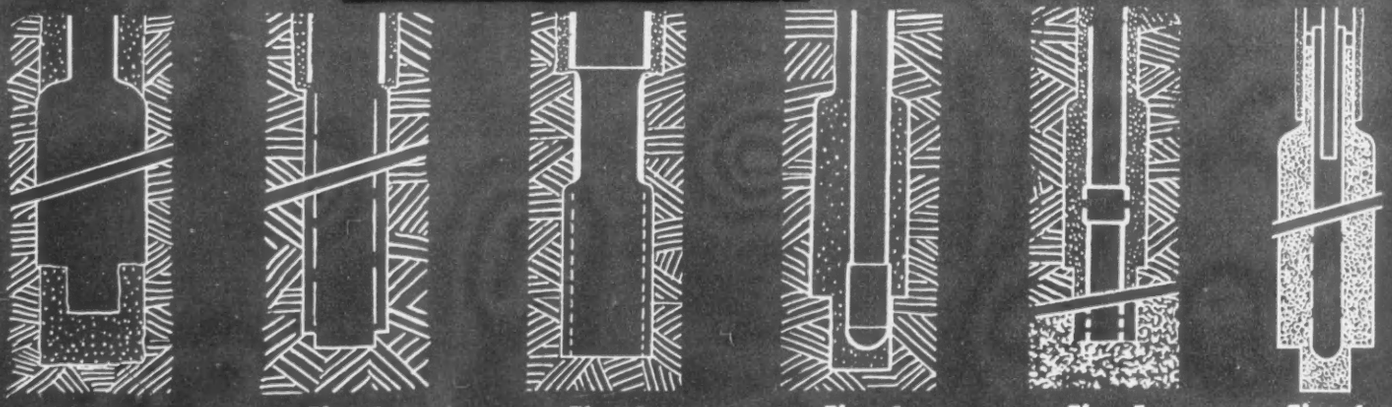

Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6

These typical uses illustrate a few of the many worthwhile applications of the Baker Rotary Wall Scraper.

Figure 1—WATER SHUT-OFF TESTS are made after rat-holing below the shoe, "wall scraping" for a vertical distance of 5 feet or more to the gauge of the original hole (or slightly beyond). Figure 2—ENLARGING HOLE TO SET CASING OR LINER with maximum ease and safety. Figure 3—REMOVING MUD SHEATH from the face of the formation to permit cement to bond with original formation. This same procedure is used to scrape the face of the oil sand to increase production. Figure 4—BOTTLENECKING to insure complete encasement of the shoe joint with cement; also to minimize hazard of channeling at this vital point. Figure 5—ENLARGING HOLE FOR C.P. JOB—showing "bottlenecked" section with casing or liner serving as water string above, and oil string below, the cementing point. Figure 6—GRAVEL PACKING is easily and effectively performed when the hole has been enlarged with a Baker Rotary Wall Scraper.

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HOUSTON • LOS ANGELES • NEW YORK

The Changing Panorama

Change the Name to Taxoline

ABOUT the Gasoline tax. Here are some facts that are surprising—but true:

U. S. motor vehicle owners paid $1.650 billion in gasoline taxes in 1947, or equal to $1.60 for every minute of elapsed time during the Christian Era.

It takes a full week's pay for the typical worker in the retail trade just to pay his gasoline tax each year.

The highest general sales tax in the U. S. is 3 percent of the retail tax—but the average gasoline tax is 33 percent.

Before it's scrapped the average new motor vehicle bought in the U. S. today will run up $547 in gasoline taxes even without any increase in tax rates.

Today, on a national basis, each cent of gasoline tax rates produces twice as much revenue as in 1930.

During the useful life of an automobile tire the American car owner pays $126 in gasoline taxes—more than eight times the cost of the tire.

Gasoline taxes each year take more than federal income taxes from the pockets of most American motorists.

At prevailing tax rates each American baby can expect to pay $2000 in gasoline taxes during his lifetime as an average automobile operator.

Today the federal gasoline tax alone costs taxpayers more each month than total tax receipts of the national government from all sources for a full year 100 years ago.

Averaged for the country, gasoline taxes are equal to about one-half the wholesale price of gasoline.

Farm Co-ops Expand Holdings in Industry

WITHIN A very short period of time farm cooperatives have achieved a position of importance in the oil industry. Twelve regional farm cooperatives own a total of 1704 oil wells and are producing more than 50 percent of the needs of their refineries. The co-ops hold 22 percent of the agricultural petroleum business of the country, and are steadily improving this position. In addition, the cooperatives own 20 refineries with a daily crude capacity of 146,900 barrels.

These figures were released by the National Cooperative Oil Committee to show the growth of farm cooperatives in the petroleum industry during the last ten years. The committee points out that it was just ten years ago that Cooperative Refining Association of Kansas City constructed the first co-op refinery at Phillipsburg, Kansas, with a capacity of 3400 barrels daily. By late 1940, this association had drilled the first cooperative oil well. Today, this association owns 946 oil wells and has four refineries in Kansas, Nebraska and Wyoming, with a total throughput capacity of 26,900 barrels daily.

That the cooperative movement intends to strengthen its oil industry position is indicated by the committee's request that the Farm Credit Administration survey: (1) requirements of oil cooperatives for the next five years, covering crude production, refining, transportation, research and financing; (2) the possible place of the co-ops in a synthetic fuel program; (3) the degree of integration among all co-ops that might be possible at the national level.

The co-ops have a stake in foreign as well as domestic oil operations. They are importing petroleum now from South America and the Middle East and have interests in tanker fleets. Further, an international cooperative setup is planning inroads producing and marketing areas.

Small Oil Firms Grow Faster Than Big Ones

The smaller companies in the petroleum industry have been growing relatively faster than the larger concerns and they also have had higher rates of earnings. These facts were found out by Dr. Joseph E. Pogue, vice president of The Chase National Bank. In a comparison of the net worth of 30 oil companies, he discovered that 13 companies with net worth of less than $100 million each increased their net worth on the average by about 63 percent in the seven years 1941-1947. Many smaller companies increased their net worth even more.

The 11 companies of intermediate size, with net worth ranging from $100 million to $500 million, grew slightly less than 46 percent over the same period. The six largest of the 30 companies, with net worth of more than $½ billion each, grew only 44 percent.

Big Steel Given Prod by That Man from Missouri

THAT MAN from Missouri who rode into the White House behind a hearse is now trying to arrange the financial funeral of the steel industry.

Or at least steel's big brass has reason for so believing.

Mr. T's gripe, aired in his "State of the Union" message, is that the steel industry has not expanded fast enough.

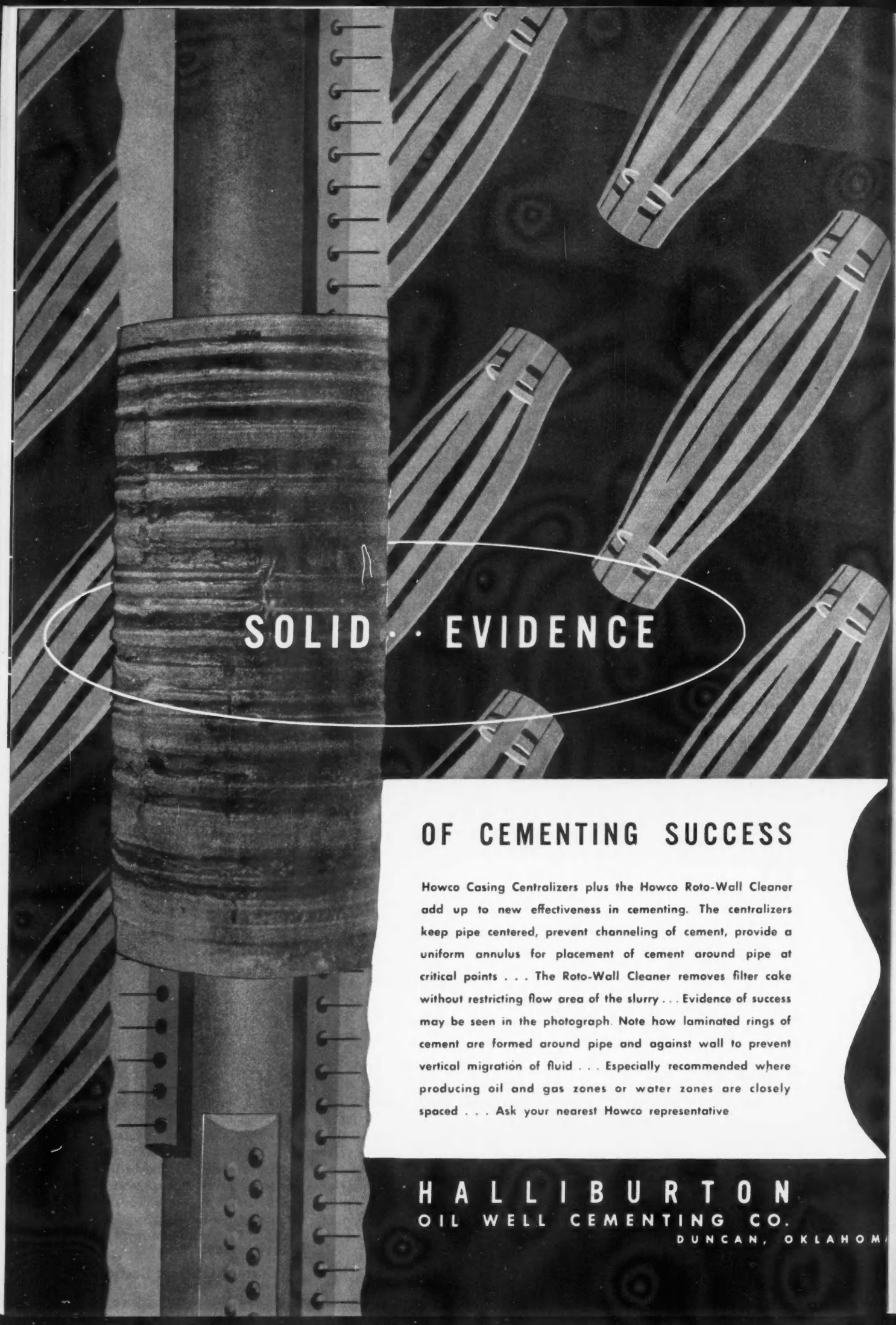
Study the situation, he told Congress, and if steel production is found inadequate, then let's lend industry the money to expand. If the steelmen balk, then the government will put up the plants itself.

Retorted the steelmen, in effect: A socialistic cure for an ailment that exists only in the mind of a haberdasher.

Walter S. Tower, president of the American Iron & Steel Institute, tossed back these figures: In 1948 the steel industry added 1,800,000 net tons of capacity. In 1949 and 1950 it will add 2,700,000 tons more and its total expansion bill will come to $2 billion.

Tower might also have added that this expansion was ordered with a worried eye to the future. The vastly expanded industry remembers that throughout the 1930's capacity exceeded demand for steel. What, then, will be done with the additional capacity if, say, five years from now, demand returns to the early 1930 level or even the late 1930's?

Another argument against expansion is that it now costs $300 to add one ton of new capacity for finished steel. This compares with $75 prewar. What if prices slump off to prewar levels? Undoubtedly the industry would be caught with its steel panties down.



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MONTHLY NEWS ANALYSIS

STOCKS AT DANGEROUS LEVEL . . . FEDERAL COMPETITION THREATENS BUSINESS
TRUMAN DISPLAYS INTEREST IN TIDELANDS OIL . . . MORE TUBULAR GOODS SEEN

Recent Big Additions Put Stocks at Dangerous Level

The oil industry has solved its supply shortage problem to such an extent that a sensational and complete reversal of its position has occurred in recent months. Once again there is more than enough supply to meet consumption requirements.

An unusually large and rapid buildup of above-ground inventories during recent months has pushed stocks to a level where they are threatening to become excessive. As a result, the industry in 1949 must return to its prewar policy of carefully regulating producing and refining rates.

The change in the industry's situation is clearly reflected by events of the past month and current statistics.

Stocks of crude and the three principal products (gasoline, distillate fuel oil and residual fuel oil) have risen sharply during recent months, increasing 48.8 million barrels during the last three months of 1948, or at the enormous rate of 530,000 barrels daily. Therefore, their combined stocks at the end of the year totaled 510½ million barrels, which was 94.8 million barrels more than a year previous.

Fortunately, a sizable segment of the industry was quick to realize the necessity of once again carefully watching producing rates, and January production allowables were reduced in Texas, New Mexico and Kansas. Consequently, it was indicated that January crude production would average almost 200,000 barrels less per day than in December. Further reductions in crude production are certain for February and March.

This reduction in crude output and a corresponding decrease in crude runs to refinery stills, coupled with an increase in burning oil consumption due to colder weather, was expected to have a beneficial effect on above-ground stocks during January. True to seasonal form, gasoline stocks continued to rise during the early weeks of January, but inventories of other products decreased.

Residual Fuel Oil Is Soft Spot in Industry's Markets

Despite large additions to above-ground inventories, petroleum industry markets were steady with the exception of residual fuel oil prices.

Due to a high rate of production at a time when consumption had decreased because of the shipping strike, residual fuel oil was the weak spot in the industry's markets. Prices for heavy fuel oils were cut three times within the past month. Reductions of 25 cents a barrel in late December and again in early January, preceded an additional cut ranging from 10 to 22 cents per barrel in mid-January.

At the end of the year stocks of residual fuel oils stood at an all-time high of 86.2 million barrels, 34.8 million barrels or 40 percent greater than 12 months before, with 18.2 million barrels of this increases occurring in the last quarter of 1948. Lower refinery output, together with a return of shipping to normal levels, following settlement of the West Coast strike, was resulting in only a small reduction of these stocks during January and they remained quite high.

Distillate fuel oil stocks, which had risen to a new peak of nearly 85 million barrels at the end of November, dropped at normal seasonal rates in December and were continuing downward in January, but also were high as compared with a year ago.

There was some concern over prospects that gasoline stocks might become excessive before the heavy motor traveling season arrived. These stocks attained a season high of 109 million barrels by January 15, with indications that they would easily surpass the all-time peak of almost 112 million barrels which existed the end of March, 1948. Smaller runs to refinery stills and proper adjustment of product yields will be needed to prevent excessive gasoline stocks.

The crude market appeared stable, although stocks at the beginning of the year were 22¾ million barrels above a year ago. At their present level of slightly over 240 million barrels, stocks of crude again were at satisfactory working levels, whereas until the fourth quarter of 1948 they had been near a 20-year low for the last five years.

Some grades of Pennsylvania crude were reduced from 6 to 24 cents per barrel in early January, but this was considered a purely local condition. The new prices, which applied to only four districts south of the general Bradford area, represented the second reduction of Pennsylvania crude within a month.

Era of Greater Government Spending, Taxing, Control

Petroleum, along with other industries, will find much of vital interest occurring in Washington during coming months. All businesses will be affected by the action Congress takes on proposals outlined by President Truman in his economic and budget messages of the past month.

It was clear from President Truman's messages to the new Congress that he will use his influence to obtain legislation on at least two matters of direct and specific interest to the oil industry. These were his requests that programs be approved "for planned use" of tideland oil under federal control and for launching government-sponsored "commercial production of synthetic fuels."

Aside from his direct references to petroleum, Truman made a number of proposals of much interest to business men in general, including those of the oil industry. Besides calling for the most costly peacetime budget in history, the President's messages were extraordinary because of their wide variety and scope and also for their enunciation of a strongly socialistic philosophy of government. The messages contained a broad program of spending for housing, education, health and social security; proposed new federal controls, including wages and prices; requested priorities and allocations for key materials in short supply, and authority for the government to construct production facilities where private industry fails to meet needs.

It is noteworthy that there was not a single reference to the dangers of an over-extended bureaucracy, nor any statement which implied any necessity

for reducing federal expenses through economies and the elimination of extravagance. On the contrary, all signs pointed to a new era of greater federal government spending and taxing, plus the imposition of additional government controls.

To finance a substantially broadened program of spending, the President called for tax legislation to yield an additional $4 billion, with most of it to come from "additional corporate taxes." Some of the revenue, he said, "should come from revised estate and gift taxes. Consideration should be given to raising income tax rates in the middle and upper brackets."

Business Is Threatened By Federal Competition

Practically all of President Truman's proposals to the new Congress were in line with his campaign pledges and previously known views. Despite their extraordinary variety, his messages actually contained only one really new and surprising suggestion. This was his threat that unless private industry expand its production facilities sufficiently to meet needs the government should be authorized to build its own plants to boost output of materials in critically short supply, such as steel.

This was a really new and startling proposal of great significance, for it constituted a new sort of business intervention beyond any heretofore endorsed by a president of the U. S. It would place the government actually in business and in direct competition with private industry. This undoubtedly was only a threat which probably will not be approved by Congress, and steel was the only business specifically mentioned by the President. Unquestionably, Congress can be counted upon to take a long look at this proposition, although it may go along with his request for a "study of the adequacy of production facilities." Nevertheless, oil and all other basic material industries might well stop and wonder about this suggestion.

True, as some argued, the government for some years has been building electric power plants in competition with private industry, but electric power has a public utility aspect previously considered to exist only in a very few other businesses and certainly not in industries like steel.

Federal Loans Proposed To Keep Production High

That at least some Congressmen go along with the President in his thinking that government should go into the business field was indicated by the introduction of a bill which proposed federal financing to maintain high levels of production. This measure, entitled "The Full Employment Act of 1950," was introduced simultaneously into the House and Senate.

It would establish a $15 million fund, to be administered by RFC, which would be directed to "actively seek" the maintenance of industrial levels called for in the President's economic report by making loans in the following order: (1) to private business enterprises, including cooperatives; (2) to states for development of their own lagging industries; and, finally, (3) to regional authorities, such as TVA.

In its full aspects the bill, if enacted, would put government into the business field in a big way. Individual states, as well as the federal government, could engage in business ventures.

Start on Synthetic Oil Fuels Industry Wanted

In asking Congress to provide funds and authorization for starting a government-sponsored commercial synthetic oil production program, President Truman requested funds which would make only a small start in this direction. The funds he proposed were less than sought in measures already introduced by Congressmen.

The National Petroleum Council, at its January meeting in Washington, expressed the oil industry attitude on this matter when it said the federal government should stay out of the synthetic liquid fuels business except for fundamental research and surveys of raw material reserves.

To explain why he thought such a program advisable, the President had this to say:

"The country must face squarely the fact that a major portion of its rapidly increasing energy requirements is being met by oil and gas, which constitute only a small portion of our energy. The prospects are that we shall become increasingly dependent on foreign sources of oil unless appropriate action is taken."

In addition, on the subject of natural resources generally, the President's budget message called for a re-appraisal of plans for using and conserving resources "in the light of the marked changes that have occurred during and since the war."

Earlier, in another general observation on natural resources, the President had told 'Congress that "Failure today to make the investments which are necessary to support our progress in the future would be false economy."

For "commercial production of synthetic fuels" the President asked for a direct appropriation of $1 million, plus "contract and other authorizations" totaling $30 million. However, such a sum would be only a small start on production of synthetic fuels. On the basis of recent government cost estimates, this would construct only one 10,000-barrel-per-day oil shale plant or only one 3500-barrel-per-day plant if coal were used.

Even before Truman made his request for synthetic fuels legislation, bills on this subject had been introduced in both the House and the Senate. The bills, which are identical, are the same as those introduced in the last Congress, and which received approval of the House Commerce Committee. They would provide RFC with a $350 million fund to lend private industry for construction of synthetic oil plants with a daily capacity of at least 5000 barrels, but carrying a proviso that the government itself may contract for the construction of several plants aggregating 30,000 barrels per day capacity if industry fails to establish within one year an adequate basis on which to develop a rapidly expandable synthetic oil industry.

Tidelands Ownership Gains Interest in Washington

Activity on the subject of offshore oil ownership increased sharply during the month, setting the stage for a showdown fight on this question both in Congress and the Supreme Court.

President Truman displayed his keen interest in tidelands oils by specifically expressing his views not once but twice in messages to Congress. "We must," he said, "adopt a program for the planned use of the petroleum reserves under the sea, which are—and must remain—vested in the federal government." Later, in his budget message, he urged Congress to enact legislation "to provide for proper conservation and planned use of the oil reserves under the sea which are vested in the federal government."

Thus, the President emphatically maintained his position that the federal government owns offshore oil, but did commit himself for the first time as being in favor of developing and using this oil as opposed to the idea advocated by some that it should be held in reserve for the future.

In contrast with this view of federal ownership, the National Petroleum Council, composed of oil industry leaders, at its January meeting recommended state rather than federal control of tidelands as "the most effective answer." Likewise, the Submerged Lands Committee of the National Association of Attorneys General urged Congress to give the states quitclaim title to the tidelands.

NPC's tidelands expression ran into criticism from Secretary of Interior

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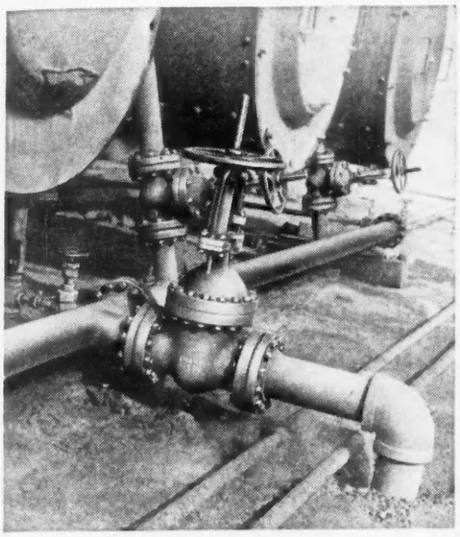

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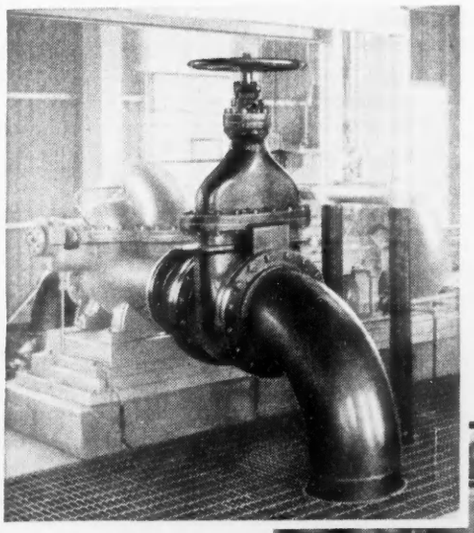
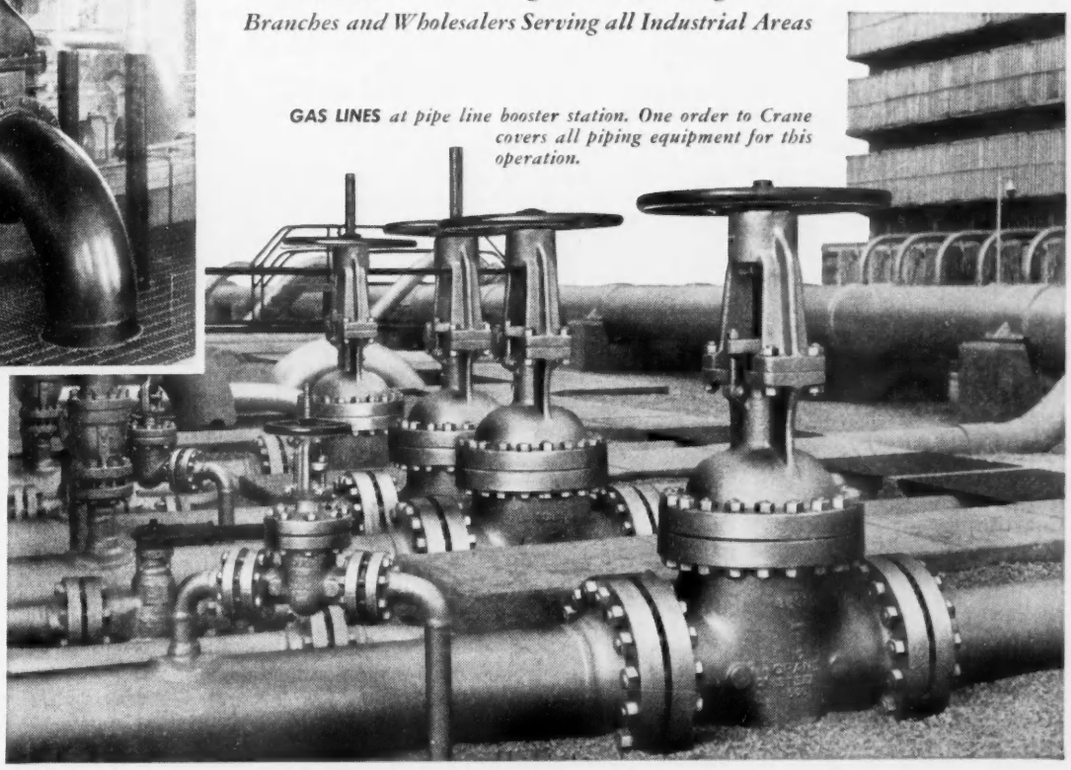


WATER CIRCULATING PUMP *in natural gasoline plant showing Crane Standard Iron Body Wedge Gate Valve, one of a complete line.*

GAS LINES *at pipe line booster station. One order to Crane covers all piping equipment for this operation.*



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Krug, who said the industry was "butting its head against a stone wall" in thinking that title ever will be vested in the states now that the Supreme Court has spoken. In effect, he told members they should forget the matter rather than cause a possible break that might irreparably damage the industry's position.

During the opening days of the new Congress five bills giving states clear title to tidelands were introduced in the House and one in the Senate. On the other side of the question, Representative Celler (D., N. Y.), introduced a bill which would confirm federal title. The bills are the same form as those presented to the preceding Congress, which passed a state quitclaim title bill by a vote of 257 to 29 in the House, only to have it fail to reach the Senate floor for a vote.

As the new Congress assembled in early January, the U. S. Supreme Court granted Texas and Louisiana two weeks in which to file objections to the tidelands suit initiated by the Department of Justice December 21.

Texas Attorney General Price Daniel asked the court to reject the federal government's suit, charging that U. S. Attorney General Clark lacked authority to bring the suit "because the Congress has not in the first instance asserted the rights herein alleged against the State of Texas." He suggested that Supreme Court might await action by Congress.

Secondly, the Texas attorney general let it be known that he would ask for the right to develop the evidence fully, noting that in similar proceedings against California neither party suggested any necessity for the introduction of evidence. In this connection, Daniel urged that if a suit is permitted that the proceedings be held in a district court, which could "develop the facts more conveniently."

Louisiana Attorney General E. Kemp also asked the high tribunal to refuse to hear the case, claiming that under the Constitution no state may be sued by the federal government unless that state consents to litigation or fails to object to it as did California in her tidelands suit.

Questionable If Congress Can Enact Tidelands Bill

Meanwhile, there was an increasing feeling that the states' fight against the federal government's claim to the submerged oil lands was a lost cause.

It appeared doubtful that Congress would enact such a measure. Although a majority in Congress probably would pass legislation giving title to the states, it was considered extremely unlikely that there would be sufficient strength to obtain the two-thirds majority necessary to override Truman's certain veto. On the other hand, it was thought improbable that a federal ownership bill could muster a passing vote. Hence, Congress might not be able to enact any measure one way or the other.

Of the 257 House members who voted for the state-title bill last year, 200 are members of the new Congress. Of the 29 who voted against it, 27 are back. There were 141 "not voting" and of these only 89 returned. Three voted "present" and two of these are in the House now.

More Tubular Goods, Line Pipe Indicated for 1949

An improved steel supply situation for the petroleum industry in 1949 is indicated, but some shortages will still exist. There may be some scarcity of tubular goods, and line pipe is certain to remain short.

A sharp rise in 1949 steel output for the oil industry was reported by the National Petroleum Council's steel requirements committee following a meeting in January with the steel industry's products advisory committee.

As against the industry's estimated steel needs in 1949 of 1,891,000 tons of oil country tubular goods (casing, tubing and drill pipe), steel authorities estimated an output of 1,803,000 tons. This would be 7.7 percent higher than the 1,674,000 ton output in 1948.

For line pipe, 1949 output was estimated at 2,553,000 tons, up 14.9 percent from the 2,221,000 tons for 1948. This output, however, would be far below the industry's estimated requirements of more than 3.5 million tons.

Gray Market Is Important Source of Tubular Goods

Gray markets and other irregular channels played an important part in the oil industry's tubular goods supply in 1948. This is revealed in a survey made by the Independent Petroleum Association of America, with 249 of its members in every principal oil-producing area replying to the questionnaire. On the basis of the survey, IPAA concluded:

Whereas U. S. operators normally buy 92 percent of their tubular goods from regular sources at regular mill or out-of-stock prices and obtain only 8 percent from the use of second-hand materials, only about 61 percent of all oil field tubular goods was obtained in 1948 through regular sources and 11 percent through second-hand materials. The remaining 28 percent was purchased through irregular channels, consisting of 9 percent through "conversion" arrangements, 12 percent through gray market purchases, and 7 percent through "oil-for-steel" trades or tie-in sales.

Small operators had more difficulty buying through regular channels than did larger concerns. Operators using 200 tons of steel in 1948 were able to get only 42 percent of their purchases through regular channels, while those using 200 to 1000 tons obtained 55 percent from this source, the 1000- to 5000-ton group obtained 64 percent, and operators using more than 5000 tons got 63 percent through regular channels.

The survey also revealed that larger companies were able to take advantage of "conversion" deals to a greater extent than smaller operators. The group using 200 tons of tubular goods or less procured only one percent through such arrangements, while operators using 5000 tons or more got 14 percent by such means.

As a result of these conditions, small operators were forced to rely more heavily on the gray market and second-hand materials. Operators using 5000 tons or more in 1948 purchased only 10 percent of their needs from the gray market, but operators using 200 tons or less got 20 percent from this source. Also, the 5000-ton group obtained only 11 percent from second-hand materials as compared with 25 percent for the 200 ton or less users.

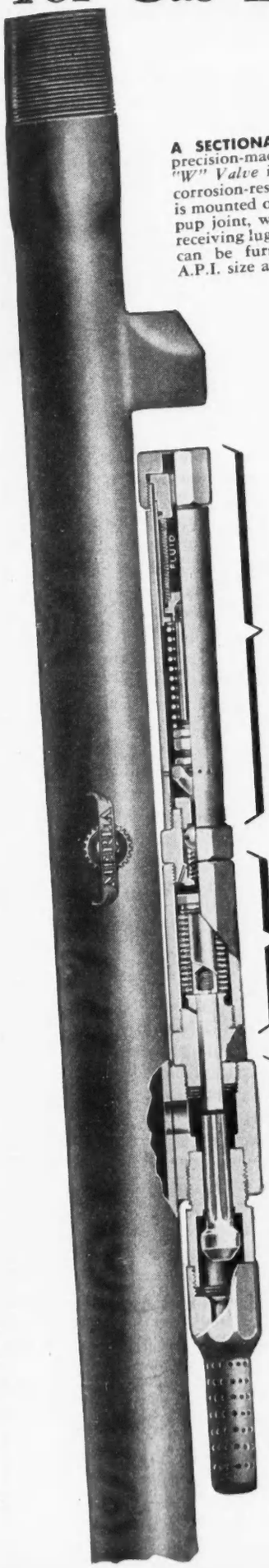
Texas Petroleum Industry Tax Increase Is Indicated

The Texas Legislature will consider many bills affecting the petroleum industry. It appeared that the $100 million surplus accumulated by the state would be wiped out, and that the matter of additional taxes would be a top-ranking subject of the new legislature. Within two days after the session got under way, bills calling for appropriations amounting to over $111 million had been introduced. Consideration likely will be given to increased taxes on natural gas, a gasoline processing tax, and revision of unitization laws.

The subject of increased taxes on natural gas and gasoline processing, as well as a greater severance tax, appeared as probable targets for those seeking greater funds for educational and road-building purposes. One proposal was for a 4-cent-per-gallon tax on all gasoline leaving the state, which would amount to approximately $320 million.

The oil and gas industry already pays 56 percent of all state property and business taxes, while all other Texas industries and taxpayers combined pay only 44 percent. Oil and gas taxes make up one-third of all tax revenues used for Texas schools. These figures do not include gasoline taxes paid by motorists, which in 1947 amounted to about $65 million.

For Gas Lift Economy in Corrosive Wells



A SECTIONAL ASSEMBLY of three precision-made parts, The *Merla Type "W" Valve* is constructed entirely of corrosion-resistant Monel. Each valve is mounted on the outside of a tubing pup joint, with guard lug above and receiving lug below. Tubing pup joint can be furnished in any standard A.P.I. size and thread.

1. Pilot Assembly *consists of a 3-ply seamless Monel pilot bellows, silver soldered to a Monel filler adapter and a threaded Monel pilot valve stem adapter. The hermetically-sealed bellows, containing fluid with a low coefficient of expansion, withstands high pressure without rupture or distortion.*

2. Power Assembly *consists of another 3-ply Monel bellows, to which is attached a drive bar. When application of gas pressure collapses the bellows, the bar is driven down into contact with the inlet valve in the main valve assembly. A bleed port permits gas pressure to bleed off.*

3. Main Valve Assembly *consists of the inlet valve thimble, inlet valve and inlet strainer cap. It is especially designed to minimize cutting action by gas and sand. The valve stem is triangular in shape; the head has top and bottom seats to give a back check action when reverse fluid flow is encountered. Operation details are fully described in Merla Tool Corp. bulletins. Write for them.*

Install the MERLA Type "W" Surface-controlled Intermitting Valve

Need artificial lift? Then here's equipment that'll pay its way until your well is produced to depletion.

The MERLA Type "W" Intermitting Valve is simple to operate, and requires a minimum of attention. It brings economy, efficiency and selectivity of gas lift production to wells where bottom hole pressure is insufficient to operate differential type valves.

What's more, this is one valve that stands its ground even in the corrosive sour gas areas of West Texas and New Mexico.

The reason? MERLA TOOL CORPORATION, Dallas, Texas, makes the Type "W" valve assembly entirely of corrosion-resistant Monel*.

This is the same rugged INCO Nickel Alloy that has been used for years in the toughest areas of the mid-continent district. It is highly resistant to sour crudes and brines. It withstands the cutting action of high pressure gas, crudes and entrained solids.

Monel brings to the MERLA Type "W" Intermitting Valve—as it does to so many other types of oil field equipment—long and reliable operation on jobs that quickly weaken and destroy other metals and materials.

Read about the construction of the Type "W" Valve in the brief captions next to the photo at the left. And for *all* the details of construction and operation of this easy-to-install, money-saving valve, write MERLA TOOL CORPORATION for their illustrated descriptive bulletins. Their address is Box 2576, Dallas 1, Texas. And they'll know just what you want if you mention this advertisement.

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MONEL* EMBLEM OF SERVICE INCO

40 Concerns Obtain Stock In Drilling Research, Inc.

Drilling Research, Inc., was backed by the confidence and cash of 40 stockholders and two licensees as it began research last month into how to make faster holes at a cheaper price and at the same time improve drilling technique.

C. P. Dimit is president of the nonprofit, cooperative research organization whose members have subscribed $777,458 toward the expense of the program. There is a three-year limit on on the program, but it is expected to extend into future years on a broader scale.

C. P. Dimit

The organization operates under a Delaware charter. In addition to Dimit, its officers are J. V. Pennington of Houston, technical director; A. E. Chester of Dallas and Earl D. Wallace of Cleveland, vice presidents; and H. H. Kaveler, secretary-treasurer.

Patented devices or techniques developed by the group will be turned over to stockholders for use without payment of royalty. Non-participating organizations or individuals desiring to use the patented equipment or techniques will be offered licenses at nominal royalties, and this revenue will be used to further research.

"Average drilling costs have increased approximately 100 percent in the period from 1937 to 1947, and have increased particularly due to the necessity for drilling to greater and greater depths in the continued search for petroleum from deep reservoirs," Dimit said.

Dr. J. V. Pennington

"It is significant that the industry has undertaken the costly and difficult job of seeking new ways and new devices for drilling wells at substantially lower than present costs," he commented.

Drilling Research has a mailing address, P. O. Box 1248, Bartlesville, Okla., and the main offices will be at Houston.

Dimit said further: "While at the present time only 42 companies are actively supporting Drilling Research, Inc., either as stockholders or licensees, the research program is regarded as one of industry-wide importance and we feel that everyone in the industry will have an opportunity to contribute, either directly or indirectly, to the success of this undertaking. A program as large as this one cannot be carried to a successful end without the interest and cooperation of everyone interested in finding means of reducing the cost of drilling oil and gas wells."

A. E. Chester

Regarding the organization of Drilling Research, Dimit declared: "The sale of stock in Drilling Research, by terms of the stockholders' agreement, closed January 1, 1949. It was impossible to contact everybody personally who might have been interested in actively supporting Drilling Research, Inc. For that reason, the stockholder ownership was obtained mainly through advertising, through use of the mails, and in a limited way through personal solicitation. I am sure there are still many companies who would have actively joined in this effort had they had an opportunity to discuss the research work directly with some one of the group actively interested in the forming of Drilling Research, Inc. The research work can still be actively supported by members of the industry through subscription to a license agreement. It is possible that if some in the industry still desire to become stockholders in Drilling Research, Inc., steps can be taken during the first quarter of 1949 by amendment to the contract through unanimous agreement of the stockholders to bring in such parties."

Earl D. Wallace

Drilling Research, Inc., stockholders are Amerada Petroleum Corporation, Harry Bass Drilling Company, Big Chief Drilling Company, California Research Corporation, Cities Service Oil Company, Continental Oil Company, Delta Drilling Company, Drilling & Exploration Company, Inc., Fain-Porter Drilling Company, Falcon Seaboard Drilling Company, Fullerton Oil Company, Gulf Oil Corporation, Kerr-McGee Oil Industries, Inc., Carl B. King Drilling Company, Lario Oil & Gas Company, Lion Oil Company, Loffland Brothers Drilling Company, W. C. McBride, Inc., Magnolia Petroleum Company, Mid-Continent Petroleum Corporation, Moran Bros., Inc., C. H. Murphy & Company, Noble Drilling Corporation, The Ohio Oil Company, Phillips Petroleum Company, The Pure Oil Company, Republic Natural Gas Company, Rowman Drilling Company, Inc., Schoenfeld-Hunter-Kitch Drilling Company, Seaboard Oil Company of Delaware, The Shamrock Oil and Gas Corporation, Signal Oil and Gas Company, The Standard Oil Company (Ohio), Stanolind Oil and Gas Company, Sunray Oil Corporation, The Superior Oil Company, Tide Water Associated Oil Company, Trinity Drilling Company, Union Producing Company, and Wheless Drilling Company.

H. H. Kaveler

Licensees are The Atlantic Refining Company and Standard Oil Company (N. J.).

Severance Tax Would Hit Many Kansas Strippers

A strongly organized group, which has selected as its basic "theme song" the popular argument that taxes are needed for education of school children, is striving to impose a severance tax on natural resources in Kansas. Another favorite aragument is that adjoining states have a severance tax and while this is true, they fail to point out that such states do not as a rule require operators to pay any ad valorem taxes in addition thereto.

Oil operators, especially in Eastern Kansas where practically all wells are of the marginal or stripper type, are gravely concerned. Their ad valorem taxes have been mounting year after year despite a decline in production. Today such taxes are so high that many stripper properties are close to or have passed the economic limit and may be abandoned if a severance tax measure is passed. Excessive taxes always force abandonment of stripper wells, and once abandoned such properties seldom are reopened because the expense is too great.

Looking Ahead

● LOOK FOR curtailment of production rates, especially in Texas and possibly in Louisiana and Oklahoma. As a result of unusually sharp additions to above-ground stocks in recent months, there does not seem to be any necessity to further increase inventories of crude and products as in 1948. This means that the approximately 250,000 barrels a day added to storage in 1948 can be utilized to supply much of the increase anticipated in demand for 1949.

● A CRUDE OIL price cut is unlikely at this time, despite growth of stocks in late months. Present situation will have to become worse or show no signs of being cured before there is danger of a general reduction in crude prices.

● AN INCREASE in quantity of tubular goods available for drilling in 1949 seems probable. Steel mills are planning to manufacture a greater volume than the record amount made in 1948. Some additional tubular goods probably also will come from greater use of conversion methods.

● MORE WELLS will go on the pump in 1949 than in 1948. Several areas which have been predominantly flowing regions show signs of breaking over into the pumping class soon.

● THE NECESSITY of reducing domestic production rates because of recent large additions to above-ground stocks will result in independent producers again raising a protest against rising imports of foreign oil.

● STOCKS OF GASOLINE will reach an all-time high before the end of March, 1949. Mid-January gasoline inventories were near the 112-million barrel peak attained in March, 1948, and may be expected to continue to increase during February and March.

● LOWER REFINERY crude runs are in prospect. Unless runs to stills, at least throughout the first quarter of 1949, are kept below December peak levels, stocks of refined products will become so excessive markets will be endangered. Refiners also must adjust product yields with care, keeping output of various products closely in line with levels indicated by consumption and stocks.

● CURRENT EFFORTS of automotive engineers to increase automobile mileage per gallon is largely the result of rising motor fuel costs, which now amount to approximately one-third of all operating expenses. Overdrives, streamlining of bodies, weight reduction, supercharging, automatic transmission, higher compression engines, etc., all increase mileage per gallon. Even a 1 percent improvement would materially affect the petroleum industry. Annual gasoline consumption approximates 900 million barrels, and a 1 percent saving will reduce yearly demand by 9 million barrels.

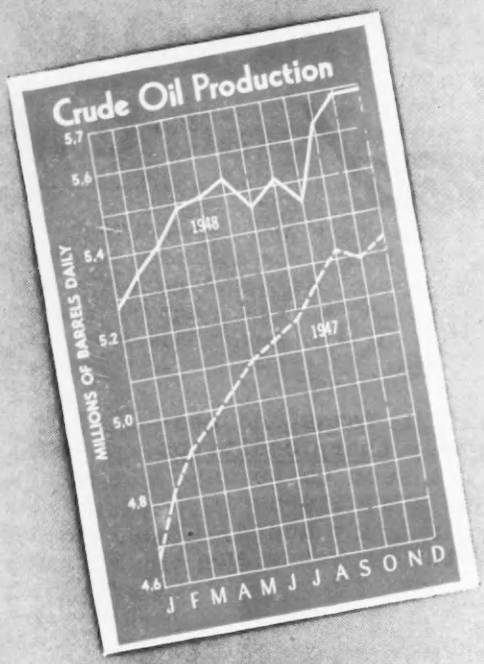
● CANADA'S OIL boom will continue to grow. Geophysical, drilling and leasing operations have increased sharply. Production in 1948 was 62 percent more than a year ago. Recent important new discoveries promise further expansion of all operations in 1949. As a result, Canada may be able to produce as much oil as it consumes by 1950. More about this on page 209.

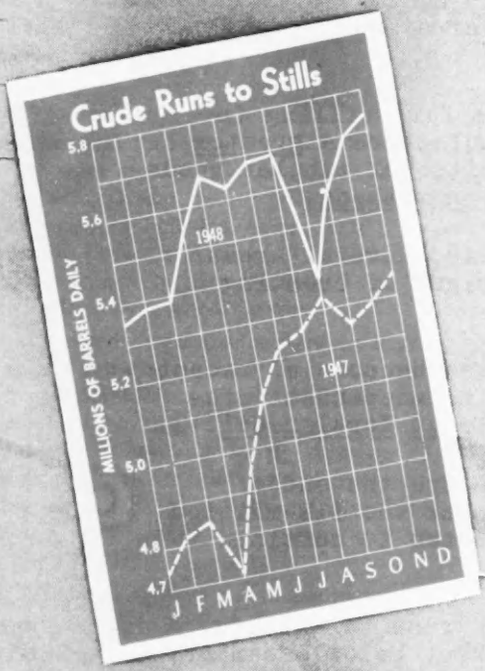
1948 Production Records

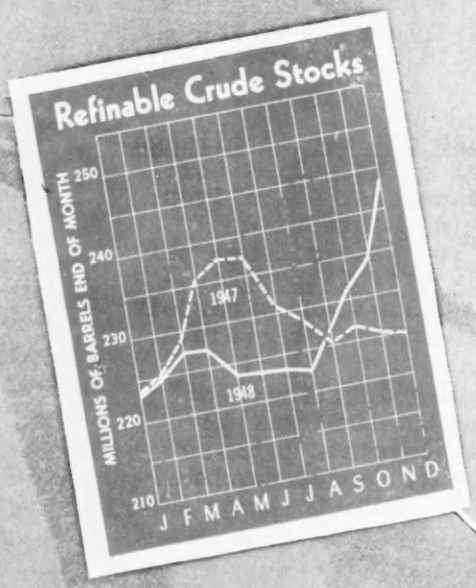
By CECIL SMITH,

THE U. S. oil industry operated its producing and refining facilities at record levels during December to climax a year of intense activity. It was a year that had no equal in its demands for petroleum products and one that saw the industry step up the pace in all phases of its work to meet the nation's oil needs. Wells were drilled in unprecedented numbers and hardly a month passed that a new all-time mark in the producing and refining branches of the industry wasn't established.

As the year closed, refiners had set another new record in the quantities of crude oil charged to their stills, and producers had equaled the record-high of November's oil output. Stocks of all the major refined products were high. Gasoline stocks were well ahead of past year's schedules by reaching levels not seen in the past several years until February or March. The fuel oils in storage were holding up well, with distillate fuel just starting downward and the heavier residuals not yet starting to move. Crude oil stocks were definitely on the upgrade and had reached levels that were on hand early in the late war for the first time.







Crude Oil and Refined Products Trends

(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month
1945:									
January	4,756	4,680	221,737	2,094	91,666	663	31,695	1,350	44,347
February	4,767	4,817	220,221	2,194	97,457	724	27,210	1,326	39,760
March	4,804	4,719	223,988	2,124	97,447	675	26,729	1,273	35,451
April	4,807	4,774	224,229	2,127	90,804	681	29,148	1,289	34,418
May	4,887	4,913	223,151	2,179	88,530	708	29,511	1,341	34,333
June	4,859	4,989	218,218	2,166	86,128	730	32,440	1,351	35,606
July	4,897	5,001	216,638	2,281	85,582	713	36,276	1,351	38,341
August	4,870	4,928	215,135	2,269	84,003	701	41,245	1,329	42,227
September	4,423	4,275	220,319	1,933	74,574	640	45,059	1,139	42,822
October	4,284	4,244	221,246	1,888	76,805	613	45,479	1,176	42,008
November	4,517	4,624	218,916	2,156	86,540	665	44,562	1,265	41,322
December	4,472	4,574	218,763	2,056	97,676	683	35,778	1,245	37,158
1946:									
January	4,625	4,520	223,442	1,914	102,394	787	28,990	1,224	34,573
February	4,719	4,651	227,220	1,884	104,836	823	25,511	1,243	34,008
March	4,414	4,661	221,400	1,900	104,161	815	29,922	1,213	32,995
April	4,673	4,663	222,480	1,943	98,744	773	32,064	1,247	35,206
May	4,785	4,794	221,592	2,016	93,960	753	33,385	1,220	38,932
June	4,896	4,836	223,140	2,055	91,971	777	38,824	1,219	41,492
July	4,922	4,856	224,351	2,102	87,778	793	46,439	1,163	45,446
August	4,836	4,856	224,157	2,189	86,745	765	54,068	1,159	48,186
September	4,790	4,839	222,417	2,143	87,021	796	62,019	1,150	54,012
October	4,785	4,736	222,177	2,117	85,952	788	76,780	1,090	55,580
November	4,823	4,684	226,453	2,162	88,587	791	68,145	1,101	52,735
December	4,725	4,789	224,473	2,168	92,742	805	59,912	1,159	47,094
1947:									
January	4,671	4,739	223,848	2,078	99,623	778	48,197	1,174	41,550
February	4,810	4,820	225,121	2,089	103,672	777	36,901	1,228	48,480
March	4,908	4,843	228,981	2,076	105,679	825	31,423	1,222	37,403
April	4,974	4,707	235,710	2,037	101,724	764	30,268	1,148	36,455
May	5,033	4,947	237,768	2,128	95,209	805	34,279	1,204	39,992
June	5,099	5,120	237,278	2,258	89,774	807	39,676	1,233	43,515
July	5,137	5,221	230,974	2,302	86,003	847	46,444	1,244	47,600
August	5,173	5,260	228,523	2,383	85,849	869	54,707	1,245	51,334
September	5,251	5,236	225,258	2,375	84,360	911	59,764	1,237	52,578
October	5,320	5,253	226,666	2,371	82,584	938	63,252	1,260	52,502
November	5,291	5,291	225,462	2,332	87,551	942	61,334	1,245	52,455
December	5,337	5,350	224,929	2,347	92,303	992	51,081	1,282	47,091
1948:									
January	5,283	5,348	223,430	2,328	102,167	1,082	41,036	1,278	44,636
February	5,353	5,380	224,880	2,264	110,999	1,127	34,590	1,295	43,156
March	5,406	5,387	227,408	2,252	111,949	1,050	32,214	1,307	41,945
April	5,484	5,540	227,278	2,396	109,829	978	34,514	1,303	43,301
May	5,502	5,668	223,820	2,486	108,552	992	40,781	1,314	48,518
June	5,544	5,632	223,481	2,529	104,518	998	48,352	1,280	52,465
July	5,522	5,631	223,124	2,494	98,839	994	58,725	1,264	58,431
August	5,577	5,621	224,211	2,532	95,445	1,038	68,818	1,248	64,096
September	5,435	5,376	228,401	2,416	90,518	961	76,320	1,154	68,005
October	5,632	5,594	234,615	2,490	92,426	1,069	82,920	1,268	72,363
November	5,680	5,682	234,305	2,516	94,416	1,077	84,655	1,300	76,579
December	5,680	5,743	243,017	2,614	104,063	1,098	77,151	1,295	76,549
December, 1948: Changes:									
In Month	....	+61	+87.12	+98	+9,647	+21	−7,504	−5	−30
In One Year	+343	+393	+ 18,088	+267	+ 11,760	+106	+ 26,070	+13	+ 29,458
In Two Years	+955	+954	+ 18,544	+446	+ 11,321	+293	+ 17,239	+136	+ 29,455

Trends

Meet High Demand for Oil

Staff Writer

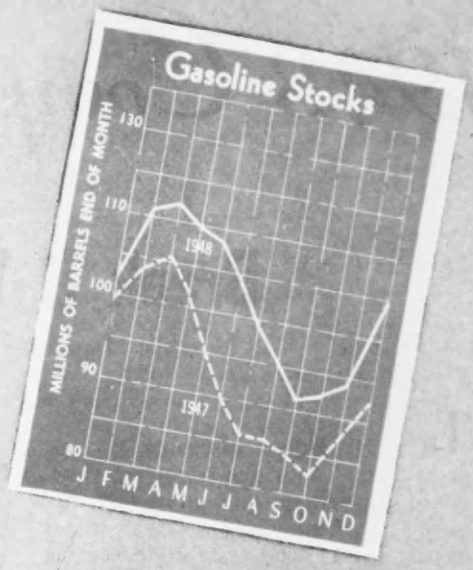
Crude production in December averaged 5,680,000 barrels daily to show no change from November's all-time peak. December's daily output topped that of last year's comparable month by 343,000 barrels and that of two years ago by 955,000 barrels a day. For the first time in history annual crude production in 1948 hit the 2 billion-barrel mark, which was an increase of 8.6 percent over the previous year's all-time high.

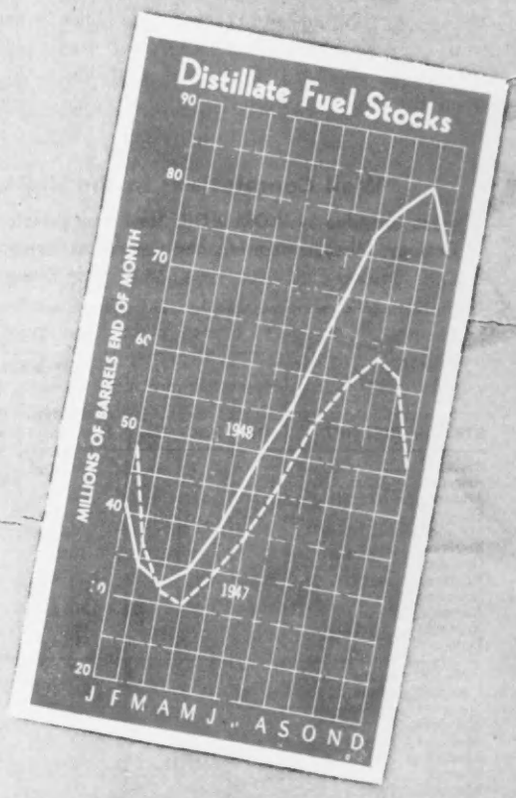
Runs to refinery stills were boosted 61,000 barrels a day over November's record runs to average 5,743,000 barrels during December. A year before they had averaged 393,000 barrels a day less and were 954,000 a day less two years previously. Domestic production failed by 63,000 barrels a day of providing the crude oil run to refineries during the month.

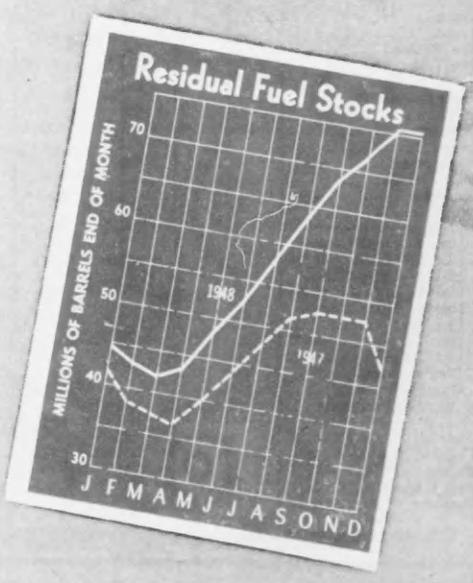
At the close of the year crude oil stocks totaled 243,017,000 barrels after gaining 8,712,000 during the final month. End of 1948 stocks were 18,088,000 barrels higher than they had been a year before and slightly more than that over stocks of two years earlier. At the outbreak of hostilities in the late war, crude stocks were slightly under 244 million barrels and this is the first time in the postwar period that they have approached that level.

Gasoline production was at its highest point during December and resulted in 9,647,000 barrels being sent to stocks, pushing finished and unfinished gasoline inventories to 104,063,000 barrels by the end of the month. A year ago only 92,303,000 barrels were in storage.

Despite increased production of distillate fuel oil during the month, stocks of these fuels started their annual downward slide. Withdrawals totaling 7,504,000 barrels from distillate stocks left them at 77,151,000 barrels. However, that amount was still 26,070,000 barrels more than was in storage a year before.







State Crude Oil Production

(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION Dec., 1948	Nov., 1948	Dec., 1947	% Diff. Dec., '47-'48	TOTAL FOR YEAR 1948	1947	% Diff. '47-'48
Alabama	1.2	1.3	1.3	— 7.7	467	396	+ 17.9
Arkansas	86.3	85.8	86.1	+ 0.2	31,594	29,990	+ 5.3
California	960.3	961.9	927.2	+ 3.6	340,681	333,102	+ 2.2
Colorado	63.3	51.4	46.1	+ 37.3	17,599	15,748	+ 11.7
Florida	0.9	0.8	0.7	+ 28.6	290	259	+ 12.8
Illinois	179.4	180.9	180.1	— 0.4	64,739	66,459	— 2.5
Indiana	24.0	26.2	14.4	+ 66.7	6,884	5,853	+ 17.6
Kansas	301.5	291.5	290.6	+ 3.8	110,101	105,346	+ 4.5
Kentucky	23.9	24.3	26.3	— 9.1	8,589	9,397	— 8.5
Louisiana	511.4	508.5	472.4	+ 8.3	180,631	160,291	+ 12.6
North Louisiana	118.1	116.1	111.4	+ 6.0	43,017	36,853	+ 1.8
South Louisiana	393.3	392.4	361.0	+ 8.9	137,614	123,708	+ 17.5
Michigan	45.5	46.7	47.2	— 3.6	16,735	16,215	+ 3.2
Mississippi	130.2	131.5	106.7	+ 22.0	45,856	35,017	+ 29.8
Missouri	0.2	0.2	0.2	— 20.0	53	55	— 3.6
Montana	26.1	26.4	24.7	+ 5.7	9,393	8,693	+ 8.0
Nebraska	0.3	0.4	0.7	— 57.1	215	229	— 6.1
New Mexico	134.4	134.6	124.2	+ 8.2	47,868	41,127	+ 16.3
New York	14.0	13.7	13.6	+ 2.9	4,696	4,762	— 1.4
Ohio	8.8	9.3	9.2	— 4.3	3,299	3,108	+ 6.1
Oklahoma	443.2	441.8	409.4	+ 8.3	153,961	141,019	+ 9.1
Pennsylvania	31.8	31.7	34.9	— 8.9	12,537	12,690	— 1.2
Tennessee	.....	.....	.....	.....	10	8	+ 25.0
Texas	2,536.4	2,546.0	2,376.0	+ 6.8	902,875	819,427	+ 10.1
Dist. 1—South Central	28.0	22.7	24.9	+ 12.4	10,037	8,120	+ 2.4
Dist. 2—Middle Gulf	181.1	180.2	163.9	+ 10.5	64,349	57,292	+ 12.3
Dist. 3—Upper Gulf	516.5	517.5	488.0	+ 5.8	183,374	174,832	+ 4.8
Dist. 4—Lower Gulf-SW.	252.7	257.4	258.0	— 2.0	92,957	88,102	+ 5.5
Dist. 5—East Central	51.9	52.1	42.2	+ 23.0	17,496	14,275	+ 22.6
Dist. 6—Northeast	418.6	426.0	413.6	+ 1.2	157,033	157,638	...
Dist. 7-B—North Central	62.1	58.2	42.1	+ 47.5	18,299	14,180	+ 29.0
Dist. 7-C—West Central	50.3	48.9	41.4	+ 21.5	16,623	13,705	+ 21.1
Dist. 8—West	741.7	746.7	648.7	+ 14.3	255,412	205,955	+ 24.0
Dist. 9—North	144.3	142.6	136.6	+ 5.6	51,326	47,957	+ 7.0
Dist. 10—Panhandle	89.8	88.7	89.2	— 0.1	31,869	31,304	+ 1.8
Utah	0.1	0.2	.....	.....	10	.....	.....
Virginia	.....	0.1	.....	+100.0	32	61	— 47.5
West Virginia	7.3	7.6	7.7	— 4.2	2,692	2,617	+ 2.8
Wyoming	149.5	157.2	137.1	+ 9.0	54,393	44,238	+ 22.9
Total United States	5,680.0	5,680.0	5,336.9	+ 6.4	2,016,200	1,856,107	+ 8.6

1948 Completions

Break 11-Year-Old Record

THE 1948 drilling campaign, greatest ever attempted by the oil industry, resulted in a new record high in well completions to far surpass the best efforts of past years. Total wells drilled during the year toppled the 11-year-old high mark that had stood since 1937, and was far ahead of the 1947 record that had been the postwar high.

Total new wells drilled in 1948 numbered 38,803 to exceed even the most optimistic estimates of the year's drilling made at the year's start. Until this year's record-breaking activity, the highest number of wells completed in a single year had been 35,213 accomplished in 1937. Since the last war, each year had seen an increase in drilling as more men and materials became available, and 1947 had been the peak year of the postwar period with 33,147 new wells completed.

Not only were many more wells drilled in 1948 than in the previous year, but the average depth was greater. In 1947, the average depth of each hole was 3404 feet, with the total footage drilled in new wells being 112,816,124 feet, which was the all-time high in footage drilled. However, total footage drilled in new wells during 1948 amounted to 134,659,093 feet for a per well average of 3470 feet or 66 feet deeper than the 1947 average.

The accompanying table shows total well completions for 1947 and 1948. These do not agree with the totals stated above, for they are total wells and include old wells that were drilled deeper. The same is true for total footage in 1948 as this figure appearing in the accompanying table includes new footage drilled in old wells.

Well Completions in the United States During December, 1948, and Cumulative for Year.

(Figures compiled by WORLD OIL Staff from private reports and other sources as follows: Illinois from Illinois Geological Survey; Indiana Division of Geology; Missouri from Missouri Geological Survey; Tennessee from Tennessee Division of Geology; Bradford, Kane-Clarendon and Allegany fields of Pennsylvania and New York from The Producers Monthly.

STATE or DISTRICT	MONTHLY COMPLETIONS, December, 1948 — NEW WELLS: Oil	Dist.	Gas	Dry	Water Input	Gas Input	Water Disposal	Total New	Total Drilled Deeper	TOTAL COMPLETIONS: Dec., 1948	Nov., 1948	Dec., 1947	Footage Dec., 1948	CUMULATIVE TOTAL January-December: Wells 1948	Wells 1947	Percent Diff.	Footage 1948	Rigs in Operation (Drilling, Rigging Up and Shut Down): Dec. 31, 1948	Nov. 30, 1948	Dec. 31, 1947
Alabama	1			1				2		2	2	4	5,609	20	30	— 33.3	98,240	4	5	2
Arizona														1	3	— 66.7	630	8	7	1
Arkansas	8			16				24		24	33	28	108,335	322	330	— 2.4	1,310,182	37	34	40
California	158		2	41				201	3	204	216	176	762,067	2,626	1,983	+ 32.4	9,274,017	259	272	275
Colorado	8	1	2	9				20		20	8	20	98,471	212	211	+ 0.5	1,136,370	25	30	63
Florida	1			2				3		3	1	1	31,378	28	29	— 3.4	186,555	5	6	4
Georgia												1		3	5	— 40.0	13,781			
Illinois	111		2	122				235		235	212	160	620,437	2,491	2,064	+ 20.7	6,517,803	263	278	214
Indiana	35			39				74		74	117	76	153,923	1,071	648	+ 65.3	2,027,267	119	136	110
Kansas	185		22	123			6	336		336	240	278	1,198,219	3,069	2,650	+ 15.8	10,381,861	320	317	338
Kentucky	21		23	14				58		58	53	72	121,741	762	1,247	— 38.9	1,526,668	76	76	75
Louisiana	108	7	6	54				175		175	185	166	856,455	2,218	1,667	+ 33.1	10,935,881	205	208	195
North Louisiana	75	3	5	31				114		114	101	124	314,484	1,444	1,023	+ 41.2	3,989,074	61	68	69
South Louisiana	33	4	1	23				61		61	84	42	541,971	774	644	+ 20.2	6,946,807	144	140	126
Maryland														1			5,259			1
Michigan	46		2	42				90		90	59	56	197,209	764	718	+ 6.4	1,745,102	109	111	118
Mississippi	11		3	16				30		30	39	33	206,413	429	470	— 8.7	3,310,034	37	39	58
Missouri				2				2		2	3	6	705	53	43	+ 23.2	19,520	10	9	3
Montana	10		2	4				16		16	34	25	46,267	305	242	+ 26.0	744,715	53	46	61
Nebraska														1	3	— 66.7	4,965			1
Nevada																		1	1	
New Mexico	35	2	7	20				64	5	69	40	73	294,302	623	607	+ 2.6	2,553,445	104	125	106
New York	89				55			144		144	142	172	199,750	1,817	1,722	+ 5.5	2,605,104	179	187	204
North Carolina															5	—100.0				
North Dakota															5	—100.0		1	1	
Ohio	31		23	24				78		78	117	107	186,177	1,324	1,347	— 1.7	3,234,213	203	218	223
Oklahoma	191	4	17	108		2		322	7	329	332	360	1,305,226	4,151	3,707	+ 12.0	14,986,638	501	537	544
Oregon															1					
Pennsylvania	91		39	12	82	16		240	2	242	292	276	415,338	3,317	3,284	+ 1.0	5,737,375	391	410	449
South Dakota														1	3	— 66.7	1,365	2	2	1
Tennessee											15	4		53	28	+ 89.3	63,470	9	9	19
Texas	707	32	34	419	3	4	3	1,202	27	1,229	1,127	828	5,313,453	12,264	9,518	+ 28.9	52,172,182	1,492	1,476	1,361
Dist. 1—South Central	28	2		22				52		52	33	28	115,969	502	371	+ 35.3	1,479,683	39	39	59
Dist. 2—Middle Gulf	21	9	7	21				58	1	59	55	56	387,811	738	629	+ 17.3	4,387,967	46	53	67
Dist. 3—Upper Gulf	44	9	3	43				99	2	101	121	85	620,696	1,118	877	+ 27.5	7,217,521	135	131	127
Dist. 4—L. Gulf-S.W.	77	4	5	65				151	5	156	143	108	753,822	1,461	1,137	+ 28.5	6,851,611	122	131	124
Dist. 5—East Central	19	1		8				28	1	29	25	15	106,873	244	167	+ 46.1	1,124,255	28	30	30
Dist. 6—Northeast	26	6		13				45		45	43	32	242,813	417	493	— 15.4	2,250,353	41	45	58
Dist. 7-B—N. Central	67		3	70				140	2	142	142	95	607,892	1,470	910	+ 61.5	4,839,933	235	210	125
Dist. 7-C—W. Central	38	1		6				45	1	46	37	19	210,666	419	288	+ 45.5	1,826,001	80	67	65
Dist. 8—West	235		3	33				271	15	286	228	171	1,414,329	2,978	2,042	+ 45.8	13,881,176	449	459	460
Dist. 9—North	106		1	131	3	4	3	248		248	214	150	652,098	2,293	2,059	+ 11.4	6,290,266	147	138	116
Dist. 10—Panhandle	46		12	7				65		65	86	69	200,484	624	545	+ 14.5	2,023,416	170	173	130
Utah	1		1					2		2	1		9,430	20	9	+122.2	80,183	11	12	15
Virginia														1	31	— 96.8	2,301			
Washington				1				1		1			3,805	3	7	— 57.1	15,010			1
West Virginia	12		54	8				74	1	75	73	80	223,872	843	913	— 7.7	2,208,399	362	370	384
Wyoming	28		2	11				41	1	42	57	31	168,917	526	268	+ 96.3	2,141,647	123	138	79
Total United States	1,888	46	241	1,088	140	22	9	3,434	46	3,480	3,398	3,033	12,527,549	39,319	33,798	+ 16.3	135,040,218	4,909	5,060	4,945

Want to Buy Some PIPE?

By
RAY L. DUDLEY
Publisher

1948 will go down in history as the year of the peak in ingenuity in getting pipe for drilling oil wells. Some of this ingenuity bears the stamp of legitimate effort to add to the supply of pipe available. Some of it, for sheer brazen affrontery on the part of "Get Rich Wallingfords" is reminiscent of the hot oil days of East Texas and the earlier "Blue Sky" days of oil promotion.

Even before the opening of 1948, some oil companies realized that many tube mills had more finishing capacity than they had steel to finish into pipe. They realized, too, that the tube mills had a reputation of integrity to sustain and that they neither desired nor could afford to enter into the "gray" or "black" market, by going out and paying premium prices for billets to be processed into pipe. Then followed a decision on the part of some oil companies which reflected the keen desire for pipe. The oil companies went out and bought billets and in some instances sheets. They paid what they had to pay to get them. Then they made deals with tube mills to process these products into pipe. The net result was a higher price for the pipe than the mills charged for their run of mill product. But the oil companies got the pipe and salved their conscience that they had not bought "black or gray" market products. Probably 9 percent of all pipe used in drilling wells in 1948 came from this source.

But some characters, to use the favorite expression of Damon Runyon, took short cuts which could be the basis for innumerable short stories.

One gentleman appeared in a certain city with a telegram from Pittsburgh "signed" by the general sales manager of a pipe company, committing that company to deliver to the gentleman sizeable quantities of pipe. He took the telegram to an oil company as an evidence of his "know-how" and was engaged as a pipe expediter at $1000 per month. We are told the idea worked so well that he presented the proposition, privately of course, to nine other companies and became their personal pipe expediter at a thousand bucks per month. The story goes that he was on the payroll of these ten companies for two months before they found out that the telegram was a fake. (Of course he didn't get them any pipe.) We are told that finally, when the pipe company whose sales manager's name was being bandied around, learned about it and got the "expediter" in its office in Pittsburgh, he signed a statement to the effect that the sales manager knew nothing of the telegram! So far, none of the ten companies have lodged a legal complaint against the "expediter."

We are told of another instance where a man, new to the oil industry, appeared with a signed commitment for a sizeable quantity of pipe, the commitment duly signed with pen and ink by the name of the sales manager of the oil field tubular goods division of a large pipe company. There seemed, even on the face of the matter, some slight doubt as to the authenticity of the document because the specifications were not drawn to cover any known pipe. The pipe mill heard about it and started checking up on the man who had the commitment. According to the story told us, he had left a trail of hotel bills, etc. Finally one day a call came to a branch office of the pipe company from the gentleman in question. He wanted to discuss certain things. The sales manager whose name had been forged happened to be in the room of the branch manager when the call came in and learned about it. So a date was set for the gentleman to appear to discuss his problem. The sales manager was to be in the room in the role of another branch manager, but just before the interview was to have taken place the gentleman called and asked to put it off as he had to go to another city immediately. Finally the sales manager got on the phone and what was said could only be printed on asbestos paper. So far as we know, nobody fell for the bogus commitment.

Still another instance involves the intense desire of the president of an oil company for some pipe "regardless of the cost." One of the thousands of tips which have been floating around to the effect that the tipster could supply X amount of pipe for X dollars, came to the purchasing agent. "Run it down to the end and get the pipe" the president told the P. A. The trail which followed could have fitted into a Fu Manchu novel. A doctor, an efficiency expert engineering firm, dark alleys, a woman, and finally the trail went back to the tipster. There wasn't any pipe! Somebody had been told that somebody else could supply it and round and round they went, only to find that nobody had anything but a tip.

The writer saw a telegram addressed to a supply store of a large organization offering some pipe at a price far above the market. The telegram came from a point as likely to have pipe as the Sultan of Sulu.

"We have run down many of these tips," one man told us, "and have found them absolutely without foundation, to the point where we just laugh now when we get such a telegram or hear about it.

"We do know of one instance where an oil company took some of the pipe we had sold it and offered it for resale at a much higher price. We got credit for being in the black market until the thing was run down. We had made a perfectly legitimate sale at the market price and the oil company couldn't withstand the temptation of taking a big profit."

California Research Corporation Opens La Habra Laboratory

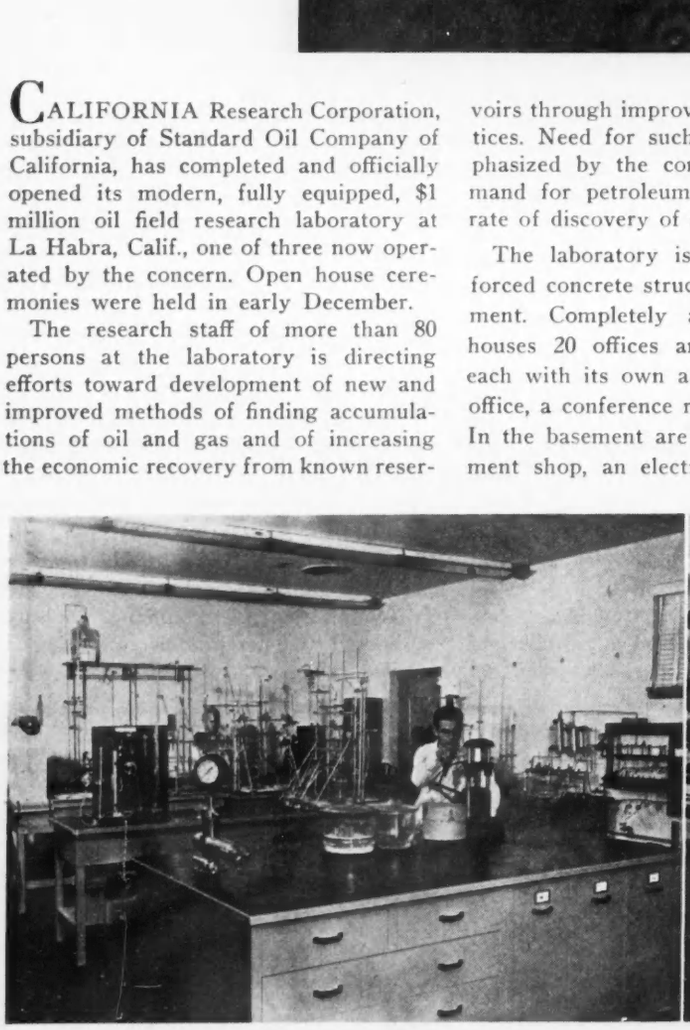
CALIFORNIA Research Corporation, subsidiary of Standard Oil Company of California, has completed and officially opened its modern, fully equipped, $1 million oil field research laboratory at La Habra, Calif., one of three now operated by the concern. Open house ceremonies were held in early December.

The research staff of more than 80 persons at the laboratory is directing efforts toward development of new and improved methods of finding accumulations of oil and gas and of increasing the economic recovery from known reservoirs through improved production practices. Need for such a program is emphasized by the continuing record demand for petroleum and the declining rate of discovery of new reserves.

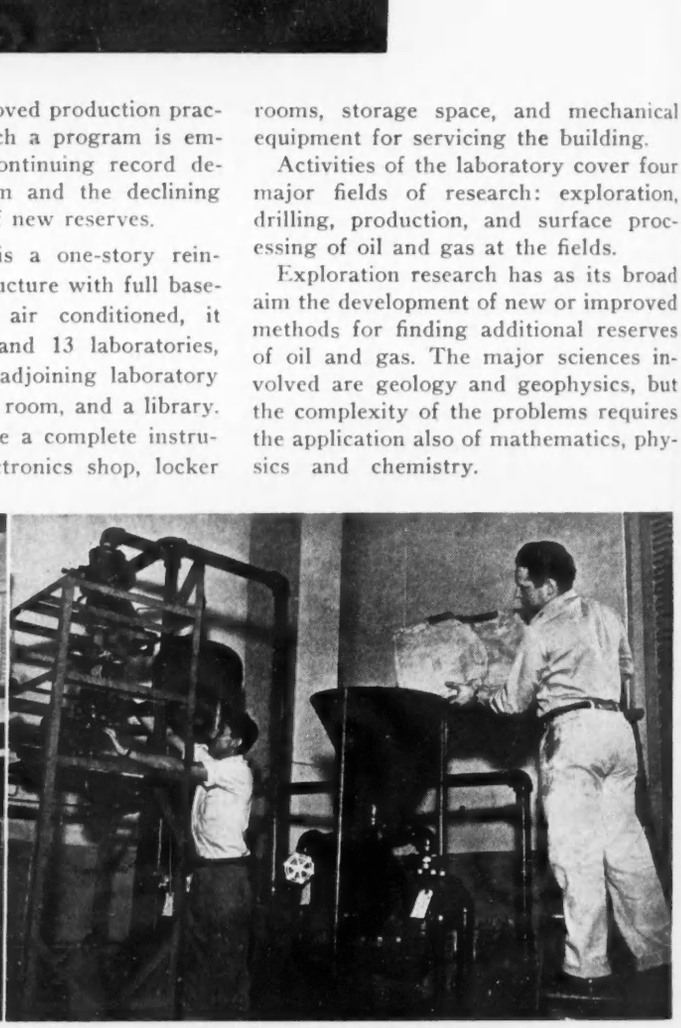
The laboratory is a one-story reinforced concrete structure with full basement. Completely air conditioned, it houses 20 offices and 13 laboratories, each with its own adjoining laboratory office, a conference room, and a library. In the basement are a complete instrument shop, an electronics shop, locker rooms, storage space, and mechanical equipment for servicing the building.

Activities of the laboratory cover four major fields of research: exploration, drilling, production, and surface processing of oil and gas at the fields.

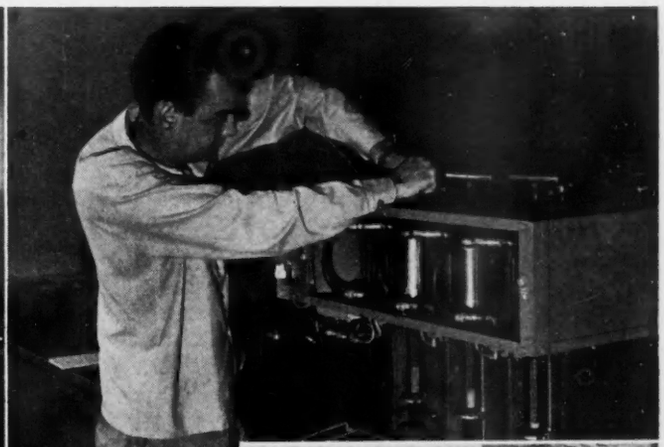
Exploration research has as its broad aim the development of new or improved methods for finding additional reserves of oil and gas. The major sciences involved are geology and geophysics, but the complexity of the problems requires the application also of mathematics, physics and chemistry.



Typical of the fully equipped laboratory areas is this room in which problems related to the flow of fluids in underground strata are studied. A wide variety of utilities are piped into the laboratories. They include air, hot and cold water, distilled water, steam, and natural gas, and AC and DC electricity.

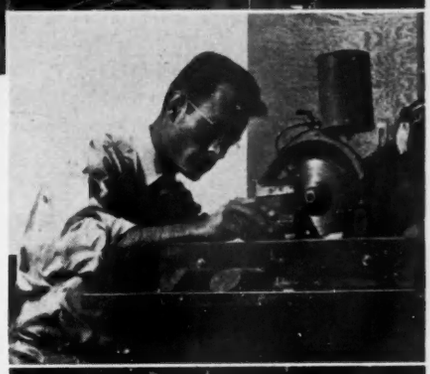


The effect of a mud cake on an oil well's productive capacity is determined by this device. Operator at the right is pouring dry mud into the mixing cone. This is one of the dozens of specially-developed pieces of equipment now in operation at the new laboratory. Shown are Bud Sanchez and Don McGee.



LEFT: Laboratory rooms have been carefully designed to provide adequate working space, sufficient lighting and easily accessible utilities. These features can be seen in this photo.

RIGHT: One of the many important characteristics of drilling fluid or "mud" is determined by this filter test equipment. The operator is Tom Roberts.



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Core sections are sawed and ground into thin sections as shown above to facilitate microscopic analysis. A diamond-studded saw blade is required to cut through the tough rock. Shown is Mel Levet.

☆

Analysis of oil and gas samples for their lighter hydrocarbon constituents is one of the many different activities. This analysis is conducted by means of a low-temperature fractionation column which operates at temperatures as low as 100 to 200 degrees below zero. The operator is Herman Dykstra.

☆

The development of improved drilling fluid or "mud" used in oil well drilling operations is one of the activities. Here, Virginia Johnson is preparing to make a viscosity test on a mud sample.

The general objective of drilling research is the development of new or improved methods and equipment for drilling oil and gas wells. At the same time it is essential that methods for completing wells be evolved which will assure the maximum potential output when the underground reservoirs are tapped. Active drilling research projects include the development of superior drilling fluids, the improvement in techniques for identifying the nature of the formations being drilled, the development of instruments for observing and controlling the progress of drilling, and the determination of best methods of completing wells under different conditions.

Production research is directed toward increasing the economic recovery of oil and gas through improving both primary and secondary recovery practices. Two very important fundamental problems are the determination of the physical behavior of oil and gas at conditions of pressure and temperature existing in the underground reservoirs, and the derivation of an exact understanding of the way in which oil, gas and water move through the reservoir rocks.

Surface processing research, as the name implies, is concerned with oil and gas after they have reached the surface, but before they have left the oil field. The goal is the development of the most efficient and economical methods for recovering natural gasoline, liquefied petroleum gases, and condensate from wellhead gas. Many of the plants to recover these products function in close conjunction with production operations, especially where gas is re-injected to maintain reservoir pressures or where cycling is practiced to recover condensate. The increasing pressures involved in these operations have posed new problems in plant design.

Head of the Oil Field Research Division is E. G. Gaylord, vice president of California Research. A graduate of the University of California, Gaylord has been connected with oil production for more than 35 years. He served as chief petroleum engineer with Standard's Producing department prior to his appointment with California Research in 1947.

Manager of the La Habra Laboratory is R. F. Faull, who was appointed to the position in July. He is a graduate of the University of California, holding B.S. and Ph.D. degrees as well as Phi Beta Kappa honors. He has been with Standard's research organization since 1937.

PROFITS ...Real and Unreal

PUBLISHED earning statements of companies engaged in the petroleum industry will show large profits for 1948. In a normal economy, such profits as will be reported would be considered extraordinarily high, and perhaps properly so, but conditions which exist today are not "normal."

Under present conditions the real consideration is, do published statements reflect real profits? If they do not, what is the true situation?

It has been stated many times recently that reported profits included certain unrealistic profits. This is not only true in theory; it is true in actual practice. Profits should be recognized as net earnings which provide cash that owners can use for their own benefit, for reinvestment in business facilities, or for increasing working funds. Much of the so-called profits reported today do not produce cash needed to run the business, and then they are taxed, causing business to suffer doubly from a cash standpoint.

Some revealing figures on this subject recently were submitted to the Subcommittee on Business Profits of the Joint Congressional Committee on the Economic Report by John F. Seal, vice president of Socony-Vacuum Oil Company. Seal used specific experiences of Socony-Vacuum Oil as the basis for his comments, and the following paragraphs have been digested from his report to the Congressional Sub-committee.

When reviewed only at some given time, the application of generally accepted accounting principles may result in the creation of an unrealistic statement of profits. Here is a typical example:

Sales	$4,000,000
Current replacement cost of products sold	3,500,000
This would result in a real profit of	500,000
Whereas by using up low cost inventories acquired in prior years the cost of sales was only	2,000,000
Or a book profit of	2,000,000

Which is $1,500,000 in excess of the real cash profit.

Without changing the physical quantities of its inventories, the dollar values of Socony-Vacuum's inventories over the last three years increased by about $37 million. This increased value shows in the company's annual financial statements as profits, but are not truly profits because they did not produce any more cash for the company to use. On the contrary, they represented cash tied up in working capital. In spite of this, the present income tax laws require that taxes be paid on these inventory "profits," which is in fact equivalent to a tax on capital.

Real vs. Unreal

In looking at profit statements it is important to understand how much of the profits are real profits which the company can disburse in any way it chooses, and how much are unrealistic profits which must be tied up in the business, as were the inventory book profits.

Another important point which needs emphasizing is that reported profits seem high because of insufficient charges against profits for depreciation and depletion of plants and equipment. As an example, during the three years ending December 31, 1948, Socony-Vacuum will charge off against income approximately $215 million for depreciation, depletion, abandonments, etc. There is no way of telling exactly how much it would cost to replace at current prices the exact equipment worn out, but it probably would be two to three times as great as the original book costs.

Profits shown in reported statements were not real profits and must be discounted to the extent that reserves for depreciation and depletion are inadequate. In other words, the profits created by not charging off enough depreciation and depletion not only did not produce cash with which to pay dividends or use for expansion, but actually depleted cash because of the necessity of paying taxes thereon. What was left from these so-

■ CONTINUED ON PAGE 42

SUMMARY OF CASH FUNDS AVAILABLE TO SOCONY-VACUUM OIL COMPANY AND HOW THE COMPANY USED THEM

(Data for three-year period ended December 31, 1948, with the year 1948 estimated)

Cash Funds Made Available:	
From operations, after eliminating all non-cash items, such as charges for depreciation, depletion, insurance reserves, etc.	$538,000,000
From borrowings from outside sources	75,000,000
From cash on hand at the beginning of the period which had to be used	89,000,000
TOTAL CASH FUNDS MADE AVAILABLE	$702,000,000
These Cash Funds Were Used:	
For replacement and acquisition of properties, plants and equipment	$395,000,000
For additional investment in foreign and domestic affiliated companies and branches (for purposes similar to above)	88,000,000
For investment in inventories and accounts receivable, less increased amounts due others for purchases, taxes, etc.	77,000,000
To pay dividends to stockholders (averaged 92 cents per share per year, or) 3.1 percent on investment	86,000,000
To pay federal income taxes (taxes affecting 3 years under review will be $102,000,000)	56,000,000
TOTAL CASH FUNDS CONSUMED	$702,000,000

LPG INDUSTRY faces Serious Supply Problems

By S. B. CROOKS
Cities Service Oil Company

AN INCREASING demand for liquefied petroleum gas products including butane, isobutane and propane is posing a serious supply problem which is not likely to be solved for some years to come. Not only is the demand increasing in the domestic market for homes and farms, but industry is beginning to draw heavily on available supplies. This is especially true of the chemical industry which last year consumed 22.5 percent of the liquefied petroleum gas produced in this country. Other industries which have experienced critical coal and gas shortages are now installing LPG storage facilities and were stockpiling during the summer months in order to have an emergency fuel supply with which to meet contingencies in the winter months.

There is under way at this time the largest expansion program for increased production in the history of the LPG industry. Completion of this program cannot be accomplished until the latter part of 1949 and some parts may carry over to early 1950. With present delivery schedules of equipment it is doubtful that a considerable increase in supply will be available soon and especially for the peak space-heating load of the winter. Such increased production as will be available will have difficulty in meeting the increased demand due to our new consumers and additional appliances for old consumers.

With the start of the war, a heavy demand for isobutane, followed by an increasing demand for 95 percent normal butane, for the production of fighting grade aviation gasoline and synthetic rubber, resulted in the installation of additional fractionators or "splitters" to finish these products, sharply reducing the supply of butane-propane mixtures for domestic systems but increasing somewhat the supply of propane.

Demand for butane for synthetic rubber production, while still sizable, is not increasing. On the other hand the chemical industry is using large volumes of LPG products, notably the butanes, under conditions which are ideal for producers. Chemical plants are being located close to LPG plants and take their requirements through short pipe lines at approximately even rates throughout the year, writing long term contracts at good prices. This proximity to supply eliminates the need for tank cars and other transportation requirements. It is economical both for the producer and consumer but must necessarily cut into supplies required in other commercial fields. This condition will ultimately necessitate a large consumer storage program or leave the domestic consumer on the short end of the supply and at higher prices.

Likewise, the oil refinery is posing problems for the LPG industry. Refinery gasoline is in extremely heavy demand; hence the refiner is using every gallon of every product that can be utilized in the production of motor fuel. Included in this category, in addition to motor fuel base produced from crude oil and cracking, are natural gasoline and butanes. Certain volumes of butane the refiner can blend directly into his motor fuel, while other quantities can be alkylated in equipment originally installed during the war for the production of aviation gasoline, then blended into motor fuels. These required volumes are so large that refiners at times are offering premiums for additional supplies of butanes. Lack of excess crude oil supplies likewise supports this situation.

Increasing demands for aviation gasoline by the armed forces, anticipated now, will require the alkylation of additional volumes of butane. This indicates a serious situation for butane, and consequently butane-propane mixtures, and may shorten supplies of this product for the domestic consumer. Some of the older and smaller natural gasoline plants will continue to produce some volumes of butane-propane mixtures as they cannot economically afford to install the expensive fractionators to further split and finish the LPG mixtures. All of this is in line with earlier forecasts of the production section of the LPG industry regarding decreasing butane availability for domestic consumers and recommendations for preparedness for utilization of propane by the domestic consumer.

The refiner can pay a higher price than the distributor can bid for the account of the domestic consumer for butanes. He can pay for butane delivered at the refinery the price of regular grade gasoline, which is about 11 cents. This, less freight averaging say 1 percent per gallon, is a price of 10 cents, compared to 6½ cents paid by most distributors. This is a powerful influence in the distribution of the butanes.

While the crude oil refiner can use the butanes, propane does not fit his situation at this time and some refiners have been persuaded to develop propane supplies, which is helping greatly at this time. However, this volume is small compared to the potential supply from this field.

Forces outside the LPG direct sales program are placing greater loads on the supply of LPG. Fuel oil and heating distillates are in short supply and advancing in price. Coal is not plentiful and is also higher priced, As a result gas companies, both natural and artificial, have been loaded to the breaking point. Unable to obtain large steel pipe to increase their capacity to deliver the

ALTHOUGH IT has been greatly expanding for several years, the liquefied petroleum gas industry is having difficulty in meeting the sharply increasing demand for its products. The liquefied gases are in very great demand for domestic purposes such as cooking and heating, especially in rural areas. They also are being used in large quantities by industry, particularly the chemical industry.

Supplies will improve as construction of new facilities proceeds and as more equipment, including tank cars, becomes available. Currently, the industry has under way the largest expansion program in its history. Completion of this program cannot be accomplished until the latter part of 1949, and some parts may carry over to early 1950.

required gas volumes, natural gas companies have placed industrial customers on notice that they will be shut off during cold weather to enable the natural gas company to supply the heating and other demands of its domestic consumers. As a result the industrial consumer is installing large storage systems to hold LPG supplies for use as a standby fuel when cut off by the gas companies. These storage systems are being filled during the summer with nominal or no winter deliveries. In addition, some of the gas companies are installing additional LPG storage systems to use for both peak load supply and emergency requirements. Practically all of this storage is suitable for propane, although some butane may be purchased. All of this places a sharply increasing load on the LPG producer.

With appliances and tanks for domestic consumers becoming available in increasing volume the pent-up demand for LPG and its services is being unleashed upon the LPG producer as a most serious problem with many handicaps in the way of its immediate solution.

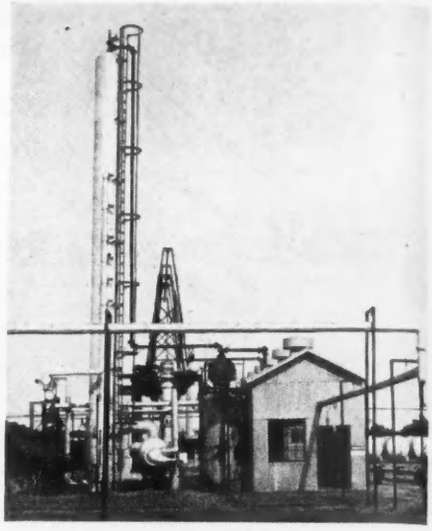
About the Author

STANLEY B. CROOKS has been an oil man since 1912 when he left his native New York to work for Kansas Natural Gas Company. In 1915 he joined Quapaw Gas Company, now Cities Service Gas Company, as district superintendent of drilling, then became chief scout for Empire Gas and Fuel Company and later was promoted to superintendent of gas production in the El Dorado, Kansas, field. In 1917 he moved to Bartlesville, Okla., as assistant superintendent of gas pipe lines for what is now Cities Service Gas Company, then through the engineering and construction department to general superintendent of natural gasoline plants for the Empire Gasoline Company (now Cities Service Oil Company). In 1923 he was made superintendent of sales and traffic for natural gasoline and for the chemical and liquefied petroleum gas divisions.

With butane demands so active by refineries, synthetic rubber, and other chemical producers, the producing branch of the LPG industry has for several years advocated that all new installations, or enlargement of old installations, for distributors and consumers be made with 200-pound working pressure tanks to permit the utilization of propane without butane mixtures. Distributors and dealers are actively following this recommendation in many areas, installing only 200-pound working pressure tanks. Some dealers, in areas where butane-propane mixtures are available in some volume, are burying these 200-pound tanks. This results in maximum flexibility, by making the installation capable of using either butane-propane mixtures or propane, whichever is available during the winter peak heating demand season.

The potential supply of propane existing in gas streams is very large at the present time. To recover any important part of this potential supply will require considerable equipment, in many cases costing as much or more than the presently installed plants. In natural gasoline plants this cost may run as high as three times the original plant cost designed to recover only 100 percent of the natural gasoline (pentanes and heavier). It will take some time to add the facilities at even the most desirable of these potential sources because of the expense and slow delivery of equipment. These heavy expenditures required to make possible the recovery of even part of the potential propane supplies readily explains the advancing prices of this product in order to make such expenditures economically desirable.

Refineries, in turning to propane recovery and sale, also have several problems. If the product is presently used as fuel, a substitute fuel must be found and often other changes are required in refinery processing in addition to the equipment required to actually recover and finish the propane.



Stabilizers and control house.

A serious tank car shortage further complicates the LPG supply picture. Unlike crude oil, refined products and natural gas which can be moved long distances via pipe line, the liquefied petroleum gas producer must have tank cars in order to meet the requirements of his expanding markets. At present the bulk of the LPG produced is being moved within tank wagon radius. This has led to a mistaken belief by dealers that their suppliers are quite assured. As tank cars become available and more distant customers served, local dealers will find their supplies curtailed and will have to readjust their markets. Tank cars are being delivered gradually but are still far behind the industry's needs. Hence, for some time cars will be short and will require the fastest possible handling both in transit and unloading in order to achieve maximum volume hauled by making the maximum

Engine room, power end.

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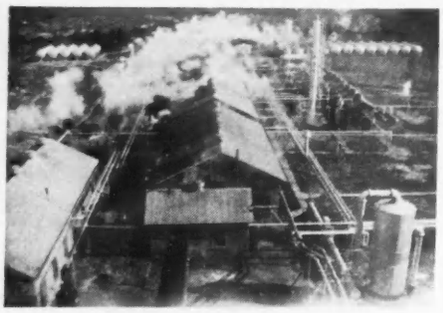


Engine buildings with storage in background.

number of trips per month. Delivery on new propane tank cars now is about 16 months after placement of order.

Industry leaders are advocating the installation of larger storage capacity on consumer premises so that sufficient backlog may be available during periods of peak load. Under such an arrangement storage could be filled during the summer months when demand is at its lowest. Such a program has been in effect in the coal industry for more than 40 years where most regular domestic coal consumers accept delivery on their next winter's supply of coal in May or June. Other products have had to develop similar programs to make their delivery economic and satisfactory.

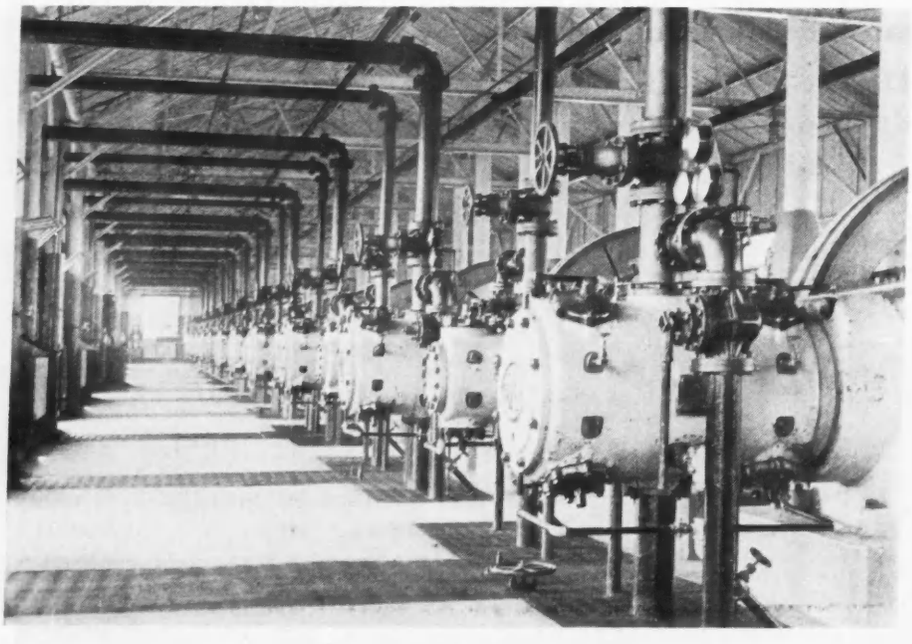
Many dealers have worked hard at promoting the installation of large consumer storage over the past two years and results are becoming apparent in some areas. These dealers will benefit directly, others very slightly, from such campaigns, as LPG manufacturers are allocating their winter supplies in proportion to a dealer's summer purchases as a fair basis for the promotion of year round deliveries of LPG in the domestic field.

Some will ask why not develop new or larger summer loads? It can be done in a limited way and still support the above program. However, so long as production during the winter plus available consumer storage cannot meet the winter peak, then all such summer consumption volumes which cannot be moved into consumer storage is lost product so far as the domestic consumer is concerned for next winter. After the program now under way for increased production is on stream, then such a program of summer load can be enlarged, so long as the two sales programs are kept relatively in step and consumers have sufficient storage capacity to handle all their operations properly.

The refiner program for additional propane production is not too well defined now. However, with better prices prevailing, we can anticipate additional supplies from the refiners. The natural gasoline industry anticipates by 1950 an increase of about 3 million gallons per day of LPG. Some of this will be butane. Probably three fourths of this increase will come from Texas, with Louisiana next, followed by Oklahoma and Kansas.

In 1947 the total LPG marketed was 1,845,000,000 gallons divided about as follows: 54.7 percent domestic; 15.5 percent industrial; 22.5 percent chemical; and 7.3 percent gas enrichment. From this can be noted the importance of the domestic consumer in this picture.

Supplies of LPG will improve as construction and equipment, including tank cars, become available, but in the meantime a great improvement in the situation could be made if the domestic consumer large storage program could be wholeheartedly pushed on a national basis wherever space heating is involved.



Engine room, compressor end.

Profits . . . Real and Unreal

■ CONTINUED FROM PAGE 38

called profits after taxes were paid, simply had to be tied up in new equipment or properties necessary to keep the company in the same operating position that existed at the beginning of 1946.

When prices go up, a lot more money is tied up in customer accounts, even though only the same quantity of goods is sold. The company must buy the raw materials, pay wages for the raw materials it produces itself, pay refining and marketing wages, and pay freight charges—all with cash. Here again, where the company's regular reports show profits after taxes, a substantial amount of cash involved in the so-called profits must be tied up in inflated accounts owed the company by customers.

Furthermore, Socony-Vacuum and other companies have had to install costly enlarged facilities to meet increased demand and this has required the use of a large amount of the so-called "unconscionable profits."

It must be realized that when the so-called profits from items mentioned in foregoing paragraphs do not produce cash needed to run the business, and then they are taxed, which requires a cash outlay, the business suffers doubly from a cash standpoint.

Unless the oil industry is permitted to deduct from its taxable profits amounts which will enable it to replace equipment and crude oil, it will gradually lose its purchasing power as well as its productivity.

To illustrate clearly the points Seal made in his memorandum, he attached a brief summary of cash funds made available to his company from all sources and showing how the company was required to use such cash funds, and this tabulation is reproduced here. The tabulation covers the three-year period ended December 31, 1948, with results for 1948 estimated.

It is clearly evident from the tabulation that during the three-year period ending December 31, 1948, with the exception of very modest dividends paid to the owners of the business, Socony-Vacuum Oil Company has been forced to reinvest in the business all of its earnings and, in addition, it has used up $164 million of its cash on hand, including $75 million it was forced to borrow.

The conditions experienced by Socony-Vacuum are true of the oil industry generally, and unless profits continue at a high level and tax increases can be avoided, the industry will be forced to curtail many of its replacement and expansion projects.

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NPC VIEW: A Free Industry Is A Healthy Industry

A FREE oil industry operating under the conditions of private enterprise is the best guarantee for the succesful development of the nation's petroleum resources. This is the view expressed by the National Petroleum Council's National Oil Policy Committee, whose long awaited policy statement has won approval of NPC and has been submitted to Secretary of Interior Krug as definitive of the industry's viewpoint.

A. Jacobsen, president of Amerada Petroleum Corporation, and chairman of NPC's oil policy committee, emphasized that the industry's policy expression is merely a verbal articulation of an implicit policy under which the oil industry always has operated. A summary of the policy statement follows:

The purpose of a national oil policy should be to allow a maximum contribution by the petroleum industry to an expanding American economy and a rising standard of living. It should maintain conditions most likely to assure adequate supplies of petroleum in both peace and war, and it should function within the free enterprise system for the equitable distribution of materials to all units of the industry. In addition, it should contribute to the expansion of trade and industrial activity and should operate so as to strengthen our free institutions in the relationship of industry to government.

The following principles are essential for a sound national oil policy:

1. National security and welfare require a healthly domestic oil industry.

2. The public interest can best be served by a vigorious competitive oil industry operating under the incentive of private enterprise.

3. The appropriate functions of federal and state governments in relation to the industry and the principles underlying their present relationships should be maintained. In this connection, it is not the proper function of government to participate in the actual operations of the industry. Further, "the operation of the American petroleum industry is grounded on state regulations of oil and gas production in the interest of conservation. . . . State authorties have proved effective in their protection of the public welfare, and the decenteralized approach has been highly successful in meeting the wide variety of conditions that prevail in different areas."

4. No government actions specifically affecting the oil industry should be taken without proper regard for the long-term effect and without consultation with the industry.

The elements of a national oil policy, designed to achieve these principles, are listed below.

Domestic Oil

1. The key industry function of oil exploration and discovery presents extraordinary difficulties and risks. It is best promoted by competitive effort and by the incentive of commensurate reward.

2. Conservation of petroleum resources will best be furthered by facilitating continued industry efforts to reduce waste and promote maximum recovery of oil through optimum-rate production, unit operation, secondary recovery, and other methods. "Where legal obstacles to unit operation exist, state laws should be clarified to encourage voluntary unitization and cooperative agreements. Also, federal tax laws should be clarified with regard to unit operation.

3. Technology is a creative force of major importance in expanding our petroleum resources and in providing adequate supplies of oil at reasonable prices. The competitive conditions under which the industry's great technological advances have been made, should be maintained.

4. The economic and efficient development of synthetic fuels to supplement natural petroleum as needed can best be achieved by private industry.

5. Provisions in tax laws which have long recognized the requirements of petroleum operations are essential to the continued development of our oil resources and, in furtherance of the public interest, should be maintained.

6. The petroleum resources of the lands beneath the marginal seas extending to the outer edge of the continental shelf can best be explored and developed under state, rather than federal, control. "The abutting states should own the lands and the resources beneath the marginal sea to the outer edge of the continental shelf."

7. Continued industry effort to find and develop oil and gas on federal public lands should be encouraged.

8. The oil industry is opposed to monopoly and believes that competition contributes to the public good.

Natural Gas

1. State and federal laws should encourage, not impede the development of natural gas recources by the industry. Gas producers should have full opportunity to sell gas to interstate carriers for re-sale by them to local distributing companies.

Foriegn Oil

1. Participation of U. S. nationals in the development of world oil resources is in the interest of all nations and essential to our national security.

2. An effective oil policy should encourage access by U. S. nationals to world oil resources on equal terms with other nationals, and stable agreements between foreign governments and private industry on a basis which will promote development by free enterprise methods.

3. The federal government should encourage foreign oil development by American nationals by efforts directed through diplomatic channels to reduce political risks involved in such foreign operations.

Imports

The nation's economic welfare and security require a policy which will encourage exploration and development efforts in the domestic industry and which will make available a maximum supply of domestic oil. The implementation of an import policy should be flexible so that adjustments may readily be made from time to time. Imports in excess of domestic needs will retard domestic exploration and development of new fields.

National Security

1. Maintenance of a vigorous oil industry in time of peace is the best way to assure reserves and facilities for time of war. A "locking up" of proven reserves by arbitrarily curtailing existing production . . . is unnecessary and would retard normal development.

2. The government should accumulate such inventories of petroleum products in peacetime as would be needed by the armed services in the early stages of a conflict. But stockpiling on a massive scale in peacetime is unnecessary.

3. Procedures for government-industry consultation should be maintained.

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1895 — 1st of Tulsa — 1949

STATEMENT OF CONDITION

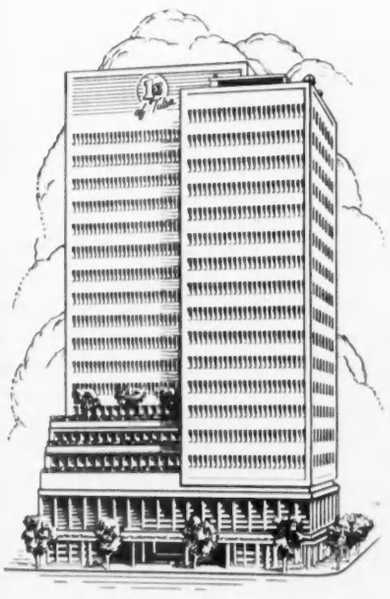
December 31, 1948

RESOURCES

Cash and Due from Banks	$61,975,141.51	
U. S. Government Securities	70,526,670.68	$132,501,812.19
Other Bonds and Securities		6,384,958.17
Loans and Discounts		52,976,726.63
Federal Reserve Bank Stock		180,000.00
Income Earned, Not Collected		294,698.08
Bank Premises		1.00
Future Banking Quarters and Fixtures		1.00
Customers' Liability Under Letters of Credit		791,311.53
Other Resources		90,018.51
		$193,219,527.11

LIABILITIES

Deposits: Individuals, Firms and Corporations	$137,594,299.38	
Banks	28,712,953.26	
U. S. War Loan Account	4,123,106.17	
Other Public Funds	12,637,603.70	$183,067,962.51
Income Collected, Not Earned		257,488.70
Taxes, Interest and Expense—Accrued		767,576.14
Letters of Credit Outstanding		791,311.53
Capital	$ 2,000,000.00	
Surplus	4,000,000.00	
Undivided Profit and Reserves	2,335,188.23	8,335,188.23
		$193,219,527.11



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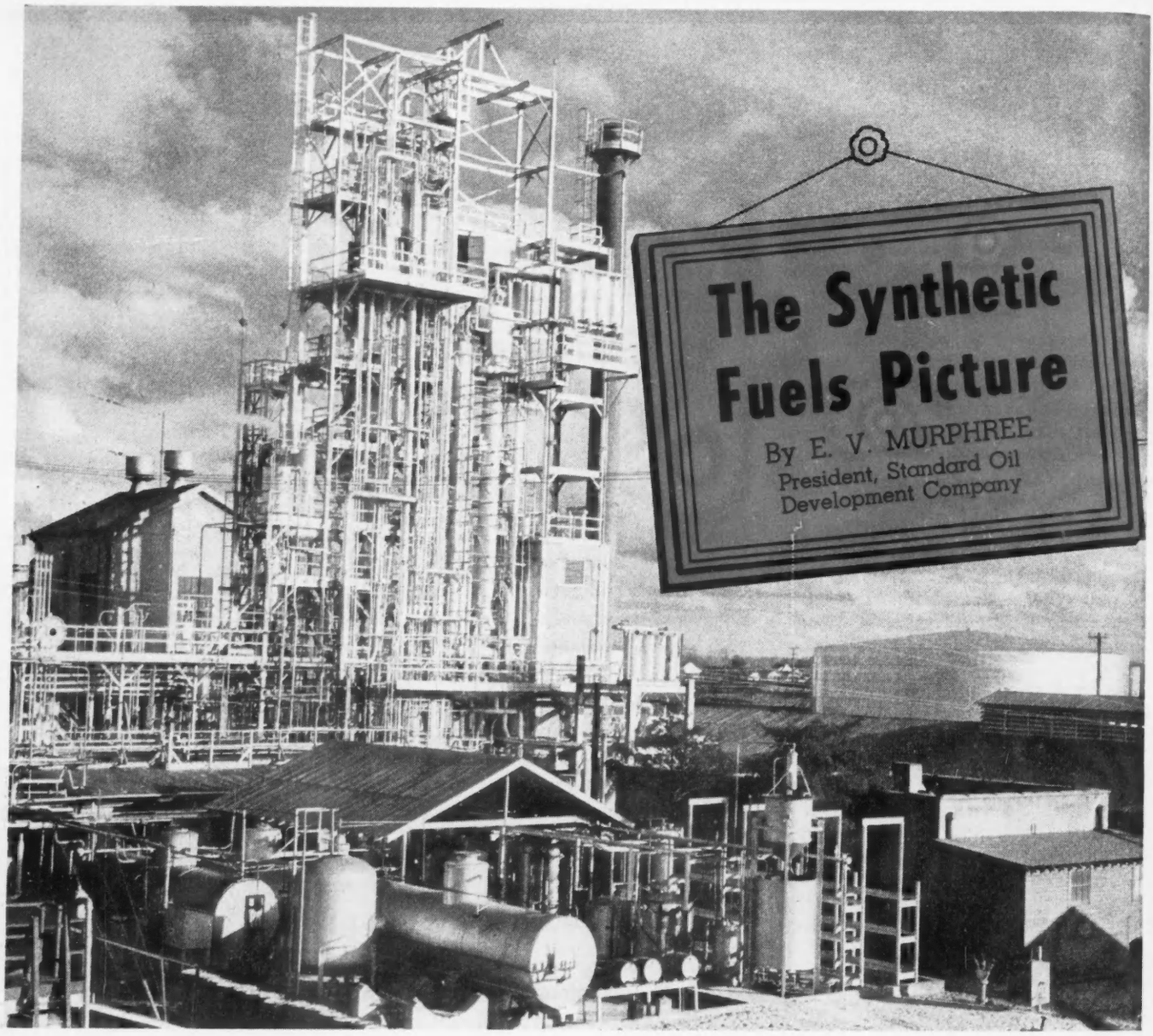


The Synthetic Fuels Picture

By E. V. MURPHREE
President, Standard Oil Development Company

Hydrocarbon synthesis pilot plant, Baton Rouge refinery, Esso Standard Oil Company.

COMPARED to gasoline and other light products from crude, the production of similar products by synthetic methods involves much larger manufacturing facilities and relatively less facilities for production of the raw materials to be used.

IMPROVED TECHNIQUES and increasing interest on the part of major oil companies, coupled with huge supplies of the raw materials such as natural gas, coal, and oil shale, mark a bright future for the synthetic fuels industry. The author gives interesting cost figures indicating that synthetic fuels may soon become competitive with fuels produced from crude petroleum.

The term "synthetic fuels" has been used in recent discussions throughout the country to denote oil products, particularly gasoline and distillates produced from natural gas, coal, oil shale and/or tar sands, and insofar as this article is concerned this interpretation of the term will be used throughout the paper.

The commercial feasibility of producing synthetic fuels depends to a large measure on the future availability of crude and its cost. For this reason a brief review of present and probable future aspects relating to oil supplies from crude petroleum may be apropos before entering into a discussion of synthetic fuels.

The production of crude oil and natural gas in the U. S. for 1947 just about balanced consumption of oil products. This consumption was at the all-time high of 5,450,000 barrels per day or about 2 billion barrels per year. The 1947 consumption was about 11 percent above the peak war year of 1945 and about 35 percent higher than the prewar year of 1941. Due to this sudden and rapid increase in consumption the oil industry was hard pushed to meet demands, and spot shortages developed. These shortages were not due, however, to a basic shortage of crude petroleum in the ground. They were in part due to lack of materials for expansion of crude production, refining and transportation and also in part to the necessity of supplying essentially world requirements from the Western Hemisphere.

U. S. Proven Reserves

The present oil reserves of the U. S. are estimated at slightly less than 25 billion barrels. On the basis of the 1947 U. S. consumption of 2 billion barrels,

the proven oil reserves represent slightly more than 12 years' supply at the 1947 consumption rate. The meaning of proven oil reserves is quite often misunderstood. It really represents the known inventory of crude in the ground. This inventory is being constantly drawn upon to supply the needs for oil products and is being constantly added to through new discoveries and proven extensions in previously known deposits. Throughout the years the proven oil reserves of the U. S. have steadily increased. For example, consumption in 1947 was the highest on record and yet the proven reserves were higher at the end of the year than at the beginning of the year. There are very extensive known deposits of crude outside the U. S., particularly in Northern South America and in the Middle East.

Total oil produced so far in the U. S. has been about 35 billion barrels, and this added to the 24 billion barrels of known reserves gives a figure for total discoveries of about 60 billion barrels. Most geologists consider that on a conservative basis we should find about as much new oil in the U. S. as we have found in the past—about 60 billion more barrels. Consumption in the U. S., however, is increasing quite rapidly, due in particular to the large shift to the use of oil for home heating. The rate of increase for 1948 is expected to be from 6 to 8 percent on total petroleum products. This is a quite high rate of increase and the rate will most likely fall off in future years. When considering increased demands, it seems unlikely, looking toward the future, that the production of crude in the U. S. will be sufficient to meet domestic requirements. For example, ten years from now the consumption of oil products in the U. S. may be of the order of 7.5 million barrels per day, which is about 40 percent higher than today. In the future, therefore, the U. S. will most probably have to supply part of its oil products requirements from imported oil or else create a synthetic fuels industry for meeting the increased requirements, or do both. To help augment U. S. requirements, crude could be imported from either northern South America or the Middle East.

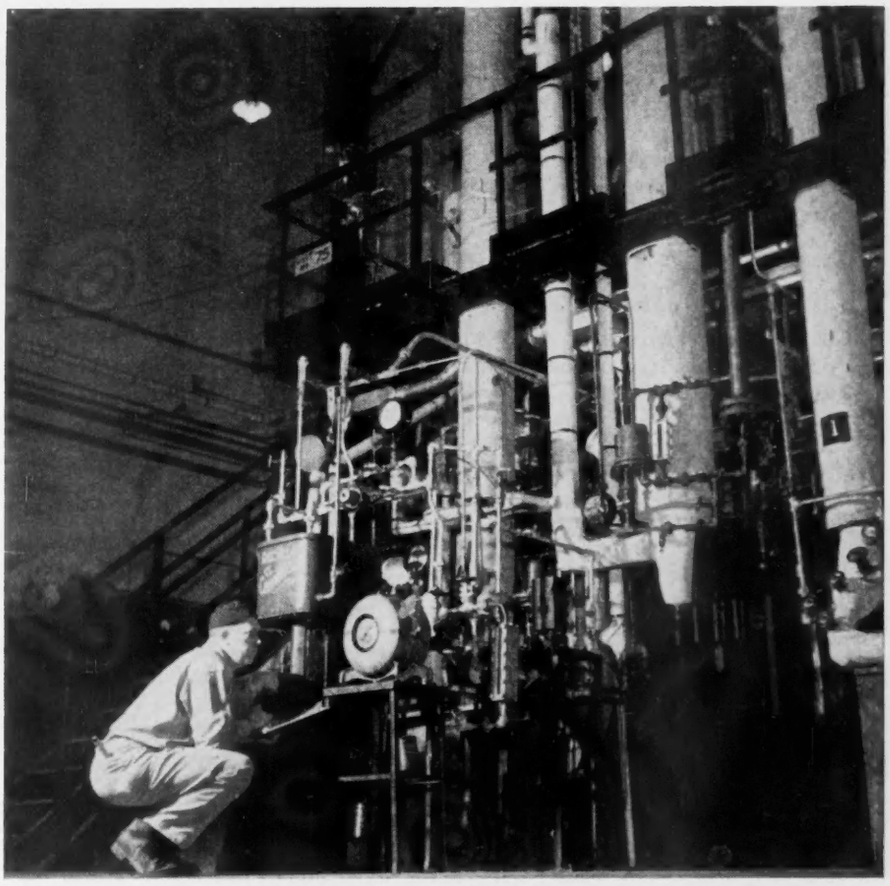
In the future, it appears likely that production of crude will be more expensive than in the past, due to higher finding costs and to the necessity in many cases of deeper drilling, along with the over-all general decrease in the value of the dollar. Due to the higher finding and producing costs for crude, production of synthetic fuels is becoming closer to broad economic application. For example, production of synthetic fuels from natural gas appears competitive with production of similar products from crude today. This, then, is one incentive for the gradual establishment of a synthetic fuel industry. The second incentive comes from national security reasons.

Natural gas is one of the most interesting materials for production of synthetic fuels, although it is limited in availability. Known natural gas reserves of the U. S. have been estimated at about 166 trillion cubic feet. If this were all converted to oil it would be the equivalent of about 16 billion barrels of oil, which is around 70 percent of the known oil reserves. The rate of discovery and extension of known reserves of natural gas averaged about 8 trillion cubic feet per year for the 15-year period ending in 1945, but its use increased rapidly over this period. Discoveries and extensions of known reserves for 1946 are about 13 trillion cubic feet and may be about 11 trillion cubic feet for 1947. It is believed reasonable to assume a rate for extension of known reserves and new discoveries for the next few years of 10 trillion cubic feet per year.

Present consumption of natural gas for purposes other than carbon black, field use, and loss is about 2.7 trillion cubic feet per year. Based on present usage an estimate has been made of the gas that will be required in the future for carbon black, field use and loss totaling 1.6 trillion cubic feet. This added to the present-day consumption for industrial use and heating of 2.7 trillion gives a total of 4.3 trillion cubic feet. New pipe line capacity has been authorized or applied for, amounting to 1.8 trillion cubic feet per year. Assuming all these pipe lines are installed, the consumption of natural gas would then be built up to about 6.1 trillion cubic feet per year. On the assumption that the rate of discoveries and extensions would be 10 trillion cubic feet per year, there would then be available without drawing on reserves, either for further pipe line and industrial use or for synthesis, 3.9 trillion cubic feet of natural gas, which would yield roughly 900,000 barrels per day of oil products, mainly gasoline. After making still further allowance for increased industrial and heating use, it is believed there will be enough natural gas supplies to produce at least some 300,000 barrels per day of oil products.

Coal Reserves

The U. S. reserves of coal are estimated to be very large, although the estimates are based on quite old figures obtained by the U. S. Geologic Survey. Estimates that have been prepared on these data indicate that reserves of coal, including lignite, amount to 3 trillion tons. Of this amount on a heating value basis about two-thirds is west of the Mississippi. Present consumption of coal in the U. S. is about 610 million tons



Edward Eckert, an operator, checks meter on hydrocarbon synthesis pilot plant.

per year and it can be seen from this figure that the estimated reserves are very large compared to the consumption. The consumption of oil products in the U. S. is increasing and will probably reach 7 million barrels per day in the next few years. If all these oil products were supplied from coal, assuming a coal consumption of ½ ton per barrel, the coal requirement would be 3.5 million tons a day, or about 1.3 billion tons per year. There are therefore enough indicated coal reserves to supply the country's needs both for coal as such and in addition coal for making all of our oil requirements for the next 1000 years or more. Considerable revision of this figure will undoubtedly be required when considering only coal that can be mined at reasonable cost and at locations where the erection of synthetic oil plants would be advantageous. Much of the coal is west of the Mississippi River and here water supply for synthetic oil plants will be a very pressing problem.

Shale deposits in the U. S. are quite large. It is estimated that shale deposits in Colorado alone, of a richness sufficiently high to warrant working, represent an oil reserve of at least 10 billion barrels. There are substantial deposits of oil shale in other states, and also there are substantial deposits of tar sands which might be processed in a way similar to oil shales. In Canada, particularly, there are large deposits of tar sands known as the Athabaska tar sands which are estimated to represent potentially an oil reserve of 100 to 200 billion barrels. In the case of oil shale, particularly in Colorado and other western states, water supply will be a major factor in determining the amount of shale that can be processed. It may be difficult to obtain sufficient water supplies to produce any large amount of oil from shale.

Fischer-Tropsch Process

For the conversion of natural gas into oil products, a process is used which originated in Germany, known as the Fischer-Tropsch process. Through work in this country the process has been radically modified from the standpoint of engineering, process details, and catalyst. There are two main steps in the process. The first is the conversion of natural gas into a synthesis gas which consists of a mixture of carbon monoxide and hydrogen. The second step involves the reaction of synthesis gas over a catalyst to produce synthetic oil products, in this case mainly gasoline. This process, as improved for U. S. conditions, has been well worked out on an experimental and pilot plant scale, and one commercial plant of about 7000 barrels per day capacity is being erected by the oil industry in this country, while plans for another of similar size recently were discontinued because of prevailing and prospective high costs of all construction, with explanation that a similar program might be reinstated about three years from now.

One method of converting coal into oil products is very similar to the method used for natural gas. This is a two-step process as in the case of natural gas, involving first the preparation of a synthesis gas and, second, its reaction over a catalyst. This second step is for all practical purposes identical for both natural gas and coal so that the development of the natural gas process has at the same time developed the second step of a process for conversion of coal to oil. Due to the difference in raw materials, the preparation of the synthesis gas from coal is quite different in terms of equipment from that required for natural gas. A considerable amount of work was carried out in Germany on production of synthesis gas, which is really just normal water gas, from coal by continuous processes as contrasted to the intermittent type of processes that have been used in this country in the past. The processes worked on in Germany had particular application to non-caking coals and do represent improvements over the discontinuous process. It is believed that still further improvements can be made in the continuous production of synthesis gas from coal and considerable work along this line is now being carried out in this country. Certain of the processes being investigated are expected to handle caking coals equally as well as non-caking coals. It is felt that this development will lead to processes that will be more economical than those developed in Germany. From a technical standpoint, therefore, the main step to be worked out for the conversion of coal to oil using the general principle of the Fischer-Tropsch process is to get an improved method for making synthesis gas from coal.

An alternate method of producing oil products from coal is by hydrogenation. This process was extensively exploited in Germany and there is a large commercial plant in England. Detailed information is available on the experience in commercial plants on hydrogenating coal in both countries. The Bureau of Mines is now erecting a demonstration plant for the hydrogenation of coal following the general lines of the German and English developments. Some new engineering features are incorporated in the demonstration plant, which, if successful, may result in economies. It is not believed, however, that production of oil from coal by the hydrogenation process will be as attractive as the use of the modified Fischer-Tropsch process.

The organic matter in oil shale breaks down and distills when the shale is heated in the range of 800 to 1000° F. One of the problems in using oil shale has been a cheap means of carrying out the heating or retorting. In the last few years, largely as an outgrowth of developments on catalytic cracking of oil, some new processes for retorting shale have been proposed and at least partially demonstrated which appear to offer considerable improvement over older processes.

The retorting of oil shale yields a rather heavy product of disagreeable odor. By hydrogenation the crude-retorted shale oil can be converted to the full equivalent of crude oil and then processed in the same way that crude is processed.

The most important new developments in production of synthetic fuels come from a new method of handling ground solids which may be catalysts or may be raw materials such as coal or oil shale. This new method is known as the "Fluidized Solids Technique" and was first developed by Standard Oil Development Company for catalytic cracking of oil and was of basic importance during the war in connection with production of 100 octane number

About the Author

E. V. MURPHREE is an international authority in the industrial application of chemical engineering and holds 13 patents in this field. He was formerly with the Massachusetts Institute of Technology as staff assistant and research associate and with Solvay Process Company as chemical engineer. In 1930 he joined Standard Oil Company of Louisiana as director of Jasco Inc., and two years later became manager of the development and research department. In 1934 he was elected vice president and director of Hydro Engineering and Chemical Company. In 1936 he was transferred to New York as manager of development and research for Standard Oil Development Company and in February, 1946, he was made executive vice president. He was elected president in August.

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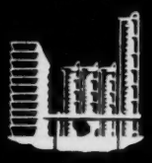

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The oil industry has been most active in research on synthetic fuels. About 20 years ago the Standard Oil Company (N. J.) group started a research and development program on hydrogenation of oil and coal involving an expenditure in excess of $10 million. In addition, large oil hydrogenation plants were erected at a cost of $16 million and operated for a number of years. Work was started on development of the Fischer-Tropsch Process for making oil from natural gas and coal but was discontinued during the war years. At the end of the war this work on the Fischer-Tropsch Process was picked up again and up to the present around $10 million has been spent on this development. In addition considerable work has been carried out on retorting of oil shale. A large scale demonstration of the process the Jersey group has developed for retorting oil shale will be made this year in cooperation with the Bureau of Mines. Other oil companies have also done a great deal of work on synthetic fuels.

A large program on synthetic fuels has been carried out by the Bureau of Mines. It is felt that the portion of their work concerned with basic research on coal hydrogenation and on the Fischer-Tropsch synthesis as well as the work they have done on oil shale has been most helpful to the industry.

Due to the large amount of research being done on synthetic fuels, the processes are being continually modified. This, together with the fact that construction costs have been continually rising makes it difficult to give anything more than an indication of the possible investments for different types of synthetic fuel plants and this is also true of the operating costs. Further, for any particular process the investment per unit of capacity will be markedly influenced by the size of the plant and its exact location. The location in particular determines the investments for water supply, transportation, housing, and other items.

Table 1 gives approximate estimates of the investments required per unit of capacity for producing gasoline from crude oil, natural gas, coal (based on Fischer-Tropsch process) and oil shale. The estimates for oil from coal assume the successful conclusion of development work now in progress on coal gasification. Estimated steel requirements and gasoline costs when processing for maximum gasoline are shown. The gasoline costs in the cases of crude oil and natural gas include 15 percent for capital charges based on the manufacturing investment and on that part of the transportation investment peculiar to the plant. The gasoline costs in the cases of oil shale and coal include 15 percent for capital charges based on both the mining and manufacturing investments, as well as on transportation investment peculiar to the plant. Other transportation costs are based on normal charges. The price for crude oil used is the present level in the U. S. Gulf with transportation charges to the refinery, and natural gas has been taken at 10 cents per thousand cubic feet in the field. The figures on mining of oil shale are based on information from the Bureau of Mines and those for coal on information from the Pittsburgh Consolidated Coal Company. The investments and steel for crude oil production are for the U. S. In the case of production of oil from coal and oil shale, housing may in many cases have to be provided and a rough cost for such housing is indicated along with possible effect on gasoline cost.

The investments and costs in the table are for a considerably higher octane number gasoline than present premium grade gasoline. The gasoline octane number level used for the estimates will about satisfy a 10 to 1 compression ratio engine which is capable of giving about 30 percent more miles per gallon than present day engines. It was felt that this quality gasoline may be required at the time there is any large production of synthetic gasoline since the use of such engines is in itself an important conservation measure.

TABLE 1

Table of Approximate Estimates on Production of Fuels

Raw Material	Crude Oil	Natural Gas	Coal (In East)	Oil Shale
Investments				
a. For max. gasoline yield $/B/D gasoline	6500	8200	8500	8400
b. Possible housing investment $/B/D gasoline (for max. gasoline yield)	....	....	2900	900
Steel Requirements For max. gasoline yield Tons/B/D gasoline	7.8	7.9	5.2	7.4
Percent Gasoline in total liquid products max. gasoline case	87	90	89	87
Raw material price assumed or estimated	$2.78/B*	10¢/MCF*	$3.20/ton	$1.00/ton
Gasoline costs for max. gasoline yield—¢/gallon				
Raw material	8.8*	2.9*	3.9	4.2
Manufacturing less credits	4.3	8.9	12.7	11.8
Product transportation	1.0	1.0	....	....
Total	14.1*	12.8*	16.6	16.0
Added cost for housing if required	....	....	1.9	0.6
Effect of increase in raw material cost	$1/B adds 3.2¢/gal.	10¢/MCF adds 2.9¢/gal.	$1/ton adds 1.2¢/gal.	$1/ton adds 4.2¢/gal.
Effect of 10 percent return on investment in				
Manufacturing or	1.6¢/gal.	3.7¢/gal.	....	....
Manufacturing plus mining	....	....	5.6¢/gal.	5.5¢/gal.

* These figures are based on crude oil and natural gas prices and not on costs.

Price Comparison

It will be noted that the production of gasoline from natural gas based on the price used for natural gas of 10 cents per thousand cubic feet compares quite favorably with production of gasoline from crude oil. This price may be at too low a level for the future. The estimated cost of producing gasoline from coal and oil shale is somewhat higher.

The figures on oil from coal in the accompanying table are for a location in the east and housing on the scale indicated may possibly not be required, depending on the location. West of the Mississippi the coal available is normally of lower heating value and hence more is required per unit of gasoline produced. Extensive housing will most likely be required and facilities will be required for transportation of products to main consumption points. This all leads to higher investments and higher operating costs.

Of the locations in the East some of the more promising are in West Virginia and Pennsylvania. Here it is believed particular locations could be chosen which would produce gasoline from coal at a lower cost than indicated in the table. In such plants isolation of the by-product chemicals produced in the process would be attractive and other special products might be produced. A 10,000 barrel per day plant would require about 5000 tons of coal per day. A 25-year coal supply for such a plant would amount to around 50 million tons.

The writer wishes to emphasize that synthetic fuel plants are not needed for, and can have little effect on, the immediate supply situation for oil products. Assuming the U. S. can rely on Western Hemisphere crude oil production in times of national emergency, it is not at present clear whether synthetic fuel plants will be essential to help supply U. S. requirements in the future. From a straight economic standpoint, production of liquid fuels from natural gas is competitive today with production of similar products from crude oil. With further improvements in manufacturing technique and possibly in mining or with further increases in the cost of finding and producing crude oil, production of liquid fuels from coal and oil shale may well become quite attractive from a cost standpoint. Substantial progress is bound to result from the large amount of research and development now being carried out.

GEOLOGICAL SIGNIFICANCE OF World's Deepest Well Bore

By ROBERT R. WHEELER
Chief Geologist, C. P. Burton

and LOUIS WALLACE
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THIS ARTICLE was prepared for WORLD OIL from a paper presented before the Eighteenth International Geological Congress in London, England, in August, 1948. Several aspects that were considered of interest to foreign geologists, especially in regard to the mechanics of The Superior Oil Company's deep drilling operation, have been deleted here as of less current interest to the industry. The original paper was one of three presented on petroleum geology by Americans.[1] It may be of some interest to report that although there were a number of papers on foreign petroleum provinces, particularly a group concerned with stratigraphy, structure and reservoir rocks of the Middle East, the majority of papers were devoted to somewhat more academic geological problems. These were divided into sections on geochemistry, metasomatism, sedimentation, geophysics, lead and zinc ore deposition, and both general and specific stratigraphic boundary problems.

The plan of the original paper was concerned with engineering and economic aspects of the deep well as well as with its geological significance. The present paper will consider in more detail the new information of a stratigraphic nature that was revealed, especially insofar as it permits certain revisions of Anadarko Basin geology as it was outlined in a previous series of articles.[2]

THE deepest well in the world was drilled by The Superior Oil Company of California to a total depth of 17,823 feet in western Oklahoma on a large structural feature which had been mapped by reflection seismograph surveys in the deep trough of the Anadarko Basin bordering the Wichita Mountains (location: NW¼ NW¼ NE¼ 11-8n-12W, Caddo County). This very expensive undertaking, although abandoned as a dry hole in August, 1947, was significant not only for its bearing upon the geological history of a province that still has been only superficially explored for oil, but also from the engineering and economic aspects involving the strength and performance of modern drilling equipment and the cost of deep prospecting. Much of the mechanics of the drilling record is well known to the industry through engineering articles already published.[3] However, certain physical characteristics of this deep drilling are worth special comment. These would include the high temperatures, more than 265° F. below 17,000 feet, and indications of abnormally high pressure. Excessive pressures were evidenced by bottom-hole pressure gauges and abnormal characteristics of the electrical log. The reversal of the flow of the self-potential current is attributed by the authors to small volumes of very high-pressure gas that invaded the heavy drilling mud opposite thin, more or less permeable sand bodies in the deeper part of the hole. There is no evidence of chemical properties in the fluids tested to explain the peculiar behavior of the self-potential curve. A similar occurrence of very high gas pressure was encountered in this same structural province by the Continental 1 Proctor farther west in Washita County. Here, according to Baxter Boyd,[4] the gas, under great pressure, impregnated the cable of the electrical logging tool such that the insulation was destroyed by the expanding gas at near-surface pressures.

Structural Aspects

Of structural importance was the fact that the deep test was centrally located on a more or less symmetrical dome of several hundred feet of closure trending northwest-southeast parallel to the majority of faulted flexures associated with the Arbuckle-Wichita-Amarillo Uplift of southern Oklahoma. But it must be appreciated that even the deeper of the consistent reflections mappable in this region are probably derived from the Upper Pennsylvanian section, whereas, much of the structural relief in better known features of the Anadarko Trough lies unconformably beneath the Mid-Pennsylvanian, Deese formation. Sand objectives in the underlying Atoka and Springer sequence, which in this area lie below 13,000 feet, are therefore at depths not easily mappable by modern seismic techniques, especially in a region of such rugged topography. Thus, it is quite conceivable that any pre-Deese structural closure may not have been tested adequately by this deep well and it is significant to note in Superior's report of its drilling operations that it cored 25-degree dips that would not in-

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LOUIS WALLACE, co-author of this paper, supervised the geological work of the Weller 1 deep test. He had been employed by The Superior Oil Company in the Rocky Mountains, Illinois Basin, West Texas and Mid-Continent since receiving his B. S. degree in geological engineering from the University of Oklahoma in January, 1937. Since May, 1948, he has been associated with Signal Oil and Gas Company in Fort Worth as division geologist.

dicate the crest of a deep structure. This possibility might be emphasized by comparison with such a producing area as Lindsay where the Upper and Middle Pennsylvanian warping gives only a very vague hint as to the pre-Deese folds and complex pattern of normal faulting that is primarily responsible for the oil accumulation in this prolific area. Or it may be that near the more deformed Wichita Mountain front the pre-Deese rocks are overturned or even thrust-faulted as they are in many producing structures of similar alignment and comparable Upper Pennsylvanian relief in the Ardmore Basin.

Regional pattern. As a matter of fact, when one considers such deep prospects as a possible source of future oil reserves, it is disconcerting to realize how little is comprehended of the forces and the movements that affected the Anadarko Basin Trough, for here, and in the adjoining north flank of the Wichita Uplift, there is a transition from thrust-faulting and overturned folds, e. g., Apache, northward into a central basin region of very little deformation. In view of the uncertainty regarding the direction and the origin of the forces that created an over-all structural relief amounting to about 30,000 feet between granite exposures in the mountains and the deep basin axis, it seems probable that a very detailed study, however academic in appearance, might achieve great practical results in delineating belts according to the intensity of deformation.

Stratigraphic Sequence

In regard to the sequence of stratigraphic units penetrated by Superior's deep well, the following represents the more or less tentative identification of major units accepted by the authors. Fortunately, the correlation of these lithologic units with better known sections to the east has recently been undertaken by the Study Group on Sedimentation and Stratigraphy of the Oklahoma City Geological Society, under the chairmanship of Richard Roberts, so that in a few months it is likely that more detailed correlations will have been established across the Anadarko Basin.

Upper Permian sands and red shales of non-marine origin are exposed in the vicinity of the deep well. These and mid-Permian evaporitic deposits extend to a depth of 3,900 feet where lower Permian marine limestones were encountered. Both the early Permian and late Pennsylvanian "Cisco" beds grade mountainward into an increasingly arkosic facies of the "Pontotoc" so that they are only tentatively separated at a depth of 4950 feet.

Reference to the correlation chart (Figure 1) will indicate that the late Pennsylvanian term "Cisco" refers to a predominantly marine sequence of Virgil age. Commonly the Cisco is lost by truncation around the flanks of the basin where the Hoxbar (of Missouri age) constitutes the Upper Pennsylvanian. But in the deep well, Cisco and Hoxbar rocks were well represented to a depth of about 10,600 feet. With one exception (a porous stained sand between 8205 and 8360), the lower Hoxbar sands that are porous and prolific producing zones at Cement were fine-grained and siliceous and on the whole not correlative with individual beds in the latter area, but the lower 500-foot section of sandy oolitic Hoxbar limestones (Checkerboard-Melton zone) definitely established correlation with better known areas.

Lower Pennsylvanian section. The underlying Deese sequence of mid-Pennsylvanian (Des Moines) age consisted of 2500 feet of gray shale with poorly developed siliceous sand members and a moderately porous 30-foot sand at the base (13,100 feet). Unconformably beneath the Deese are upper Dornick Hills (Atoka) shales with dense brown limestone beds becoming more abundant toward the base at 15,525 feet.

The lower Dornick Hills, composed of highly glauconitic siliceous limestones above, and thick glauconitic sands below, constitutes the upper group of the early Pennsylvanian (Morrow) series. This sequence is preserved only in the least truncated portions of the basin. More commonly only the underlying Springer group of lower Morrow age is present beneath the overlapping beds of later age. Here the Springer black shale sequence at 16,410 feet contained interbedded 100-200 foot sands correlative with producing sands at Chitwood, but the hole was abandoned with an estimated 1000 feet of Springer unpenetrated at 17,823 feet.

Since the relative thicknesses of these various Pennsylvanian series compared with the much thinner sequences marking the borders of the Basin have the greatest significance in evaluating the magnitude of the Pennsylvanian orogenic movements, the above data are summarized as to thicknesses.

Des Moines—2500 feet.
Atoka—2400 feet.
Morrow—2300 feet.

Correlations with other deep basin wells that penetrated the lower Springer and pre-Pennsylvanian rocks of the region indicate that the Superior test stopped about 1000 feet above the Mississippian and that it is reasonable to anticipate that the well would have en-

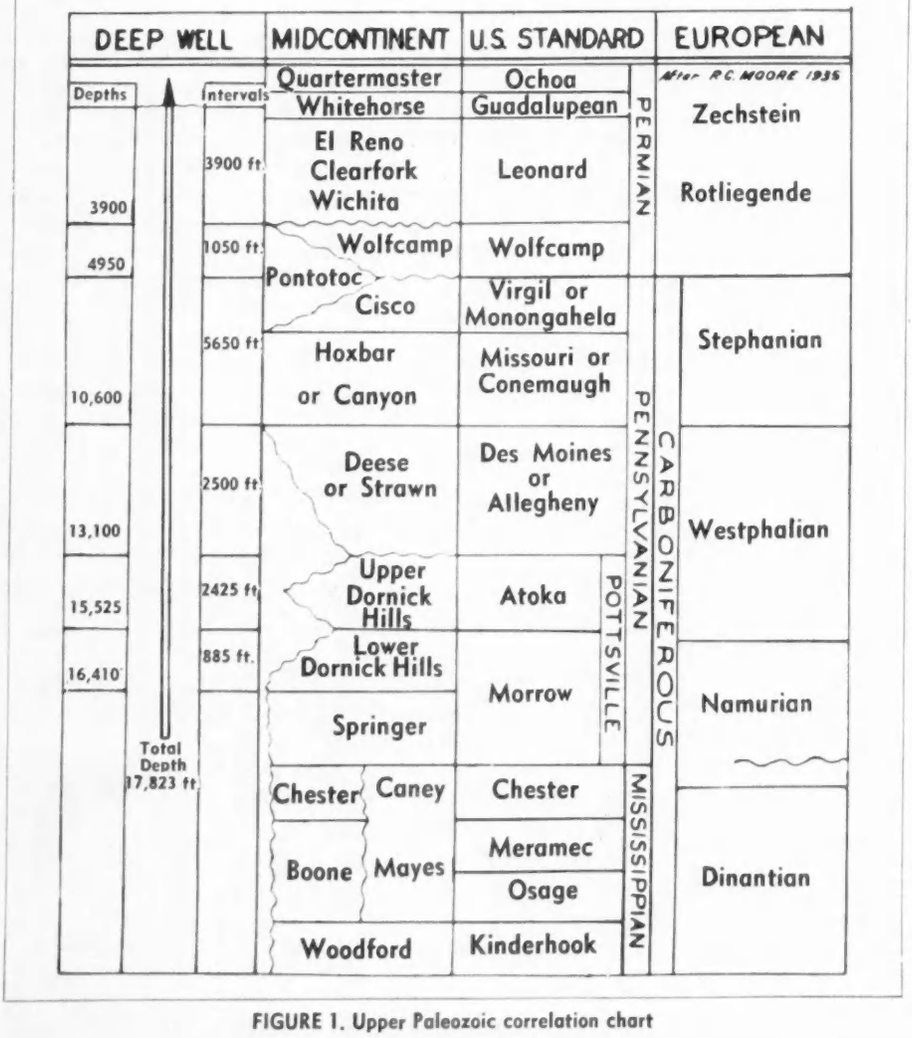
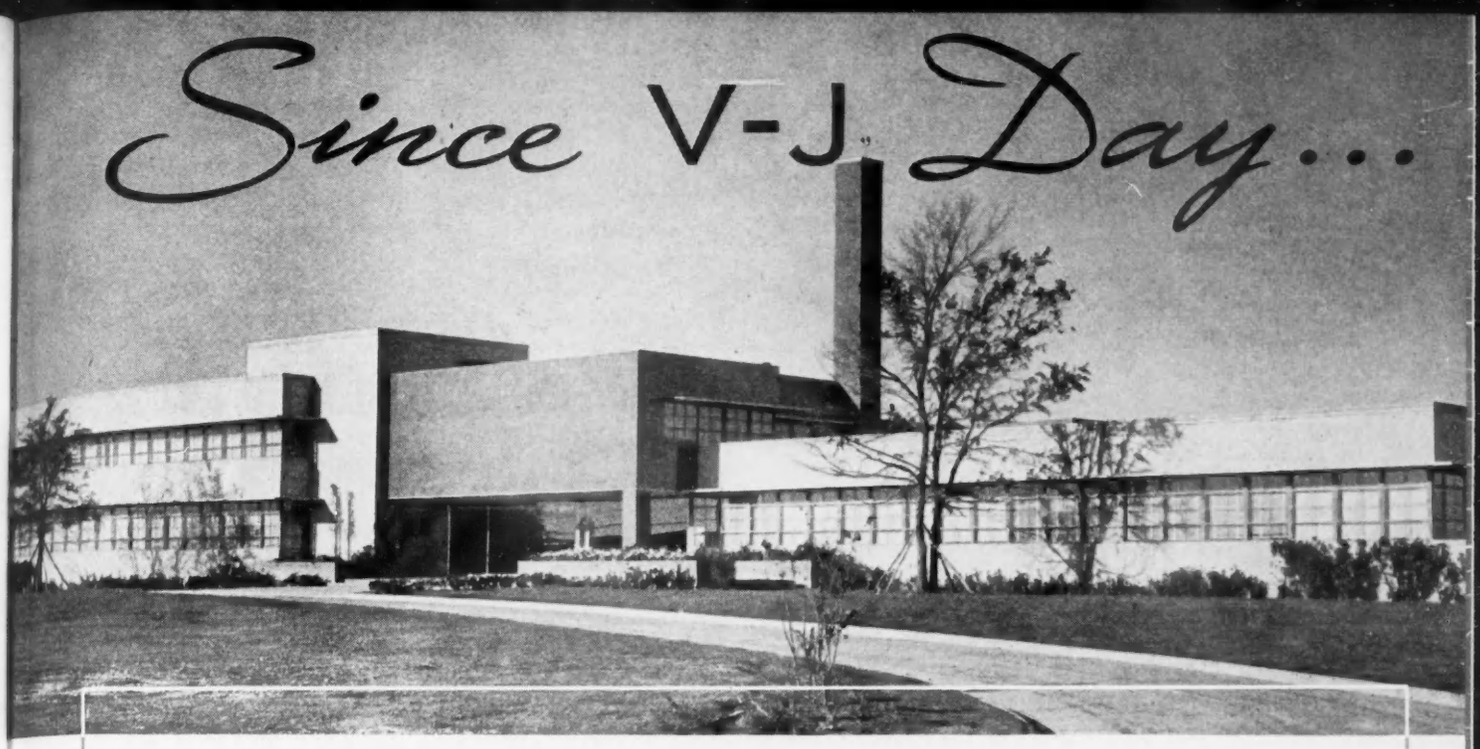


FIGURE 1. Upper Paleozoic correlation chart



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countered the Viola limestone at 20,300 feet and the pre-Cambrian at about 28,500 feet.

Revisions

The deep well supplies new data in deciphering the age and magnitude of the major orogenic events and necessitates certain revisions in the earlier paper on the Anadarko Basin.[5] These concern the distribution of early Pennsylvanian, Atoka and Morrow, rocks (Figure 2) and revised estimates of the thickness of the overlying Deese.

In finding preserved higher members of the Morrow series than have been penetrated in the southeastern embayment of the Anadarko Basin, we are better able to estimate the total thickness of early Pennsylvanian rocks in the Anadarko Basin and their rate of convergence toward the bordering highlands. A very practical aspect of this rate of convergence will be the sub-surface mapping of the wedge-out of the truncated higher Morrow sand bodies that produce, for example, in the Chitwood pool, but evidently were truncated a few miles to the northeast of the Superior well in the recent Denver test in Township 10 North, Range 9 West.

Atoka deposition. Also of great interest was the presence of Lower Pennsylvanian, Atoka, rocks which were not definitely to be anticipated ("because the Atoka rocks of the basin appear to have a very limited distribution and a nonporous facies, these probably will not produce oil in the Anadarko Basin"[6]) from the previously known distribution of correlative strata along the eastern margin of the basin. This earlier study indicated that although Atoka rocks, designated as the Moore formation, were preserved in the structurally low area of South and West Moore and north of the general Lindsay Uplift, these were not identified at the time in strategic wells deeper in the basin. Thus it was argued that the Atoka deposits represented an invasion from the southeast that did not extend across much of the basin proper. But more recently Maher and Collins[7] indicated that Atoka and Morrow rocks are present in the deeper part of the Hugoton Embayment south and west of Dodge City, Kansas. This much more extensive picture of Atoka deposition is supported by the Superior well and it now seems probable that rocks of this age will be identified in other deep tests in northwestern Oklahoma.

Atoka overlap. But while it seems to simplify the depositional history of the Anadarko Basin to find so wide a distribution of early Pennsylvanian rocks overlying areas where the latest Mississippian, Chester and Caney beds were also preserved, we are no nearer a simple explanation of the anomalous occurrence of Atoka rocks in the southeastern part of the basin. Between Moore and the Lindsay Uplift the Atoka rests unconformably upon Mississippian rocks with the Morrow locally entirely removed, whereas in the Lindsay area the Deese rests upon lower Morrow shales, but the Atoka was completely truncated. Possibly this apparent inconsistency may be explained by assuming that the Morrow sequence thinned out by reason of non-deposition between Lindsay and the Moore area (prior to the structural differentiation of the pre-Deese Lindsay Uplift) permitting the succeeding Atoka rocks to overlap upon the exposed Mississippian terrain north of the Morrow wedge-out. Subsequent events, which obviously differentiated a Lindsay Uplift from a structurally low Moore area, bevelled off the Atoka beds across the entire Lindsay and Pauls Valley Uplift. Even later, this tendency toward rejuvenated structural relief necessitated a proportionate rate of convergence of the overlapping Deese section so that a much thicker Deese sequence was deposited north of the Lindsay Uplift.

Whether or not the foregoing explanation is adequate, it is significant that a pronounced wedge-shaped uplift bisects the southeastern embayment. The north edge of this wedge trends east and west from Pauls Valley through Lindsay and Bradley to Chitwood and in each of these areas the Atoka is bevelled off and the overlapping Deese is abnormally thin.

Deese convergence. A third point of significance derived from the Superior well was the thickness of the Deese section totaling approximately 2500 feet, which is appreciably less than the 3500-foot thickest sections yet penetrated in the Basin Trough and may have some significance in regard to the magnitude of the Superior pre-Deese structure in view of the tendency for Deese convergence by onlap across rejuvenated earlier Pennsylvanian structural features. However, the Denver test to the northeast penetrated about 1700 feet of Deese, which is a thickness more or less consistent with that of the regionally much lower Superior test.

Acknowledgment is made here of the "Golden Trend" investigations of Robert M. Swesnik who made the following new points in his paper before the Denver meeting of the American Association of Petroleum Geologists April 27, 1948:

1. Atoka rocks were identified by Superior geologists in their deep test, thus extending the area of Atoka paleo-outcrop
2. Thin remnants of Springer shale were locally identified in the general Moore area, thus making superfluous the reasoning that the unconformably overlying Moore formation must be post-Springer in age
3. The term Pauls Valley Arch was first applied to the Pauls Valley-

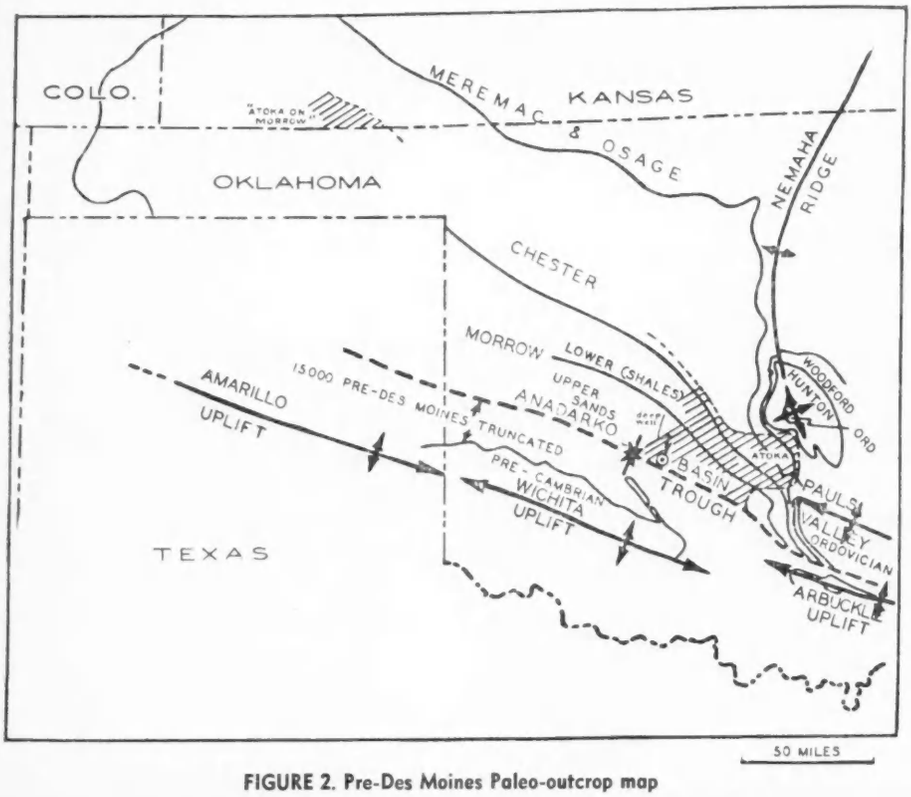
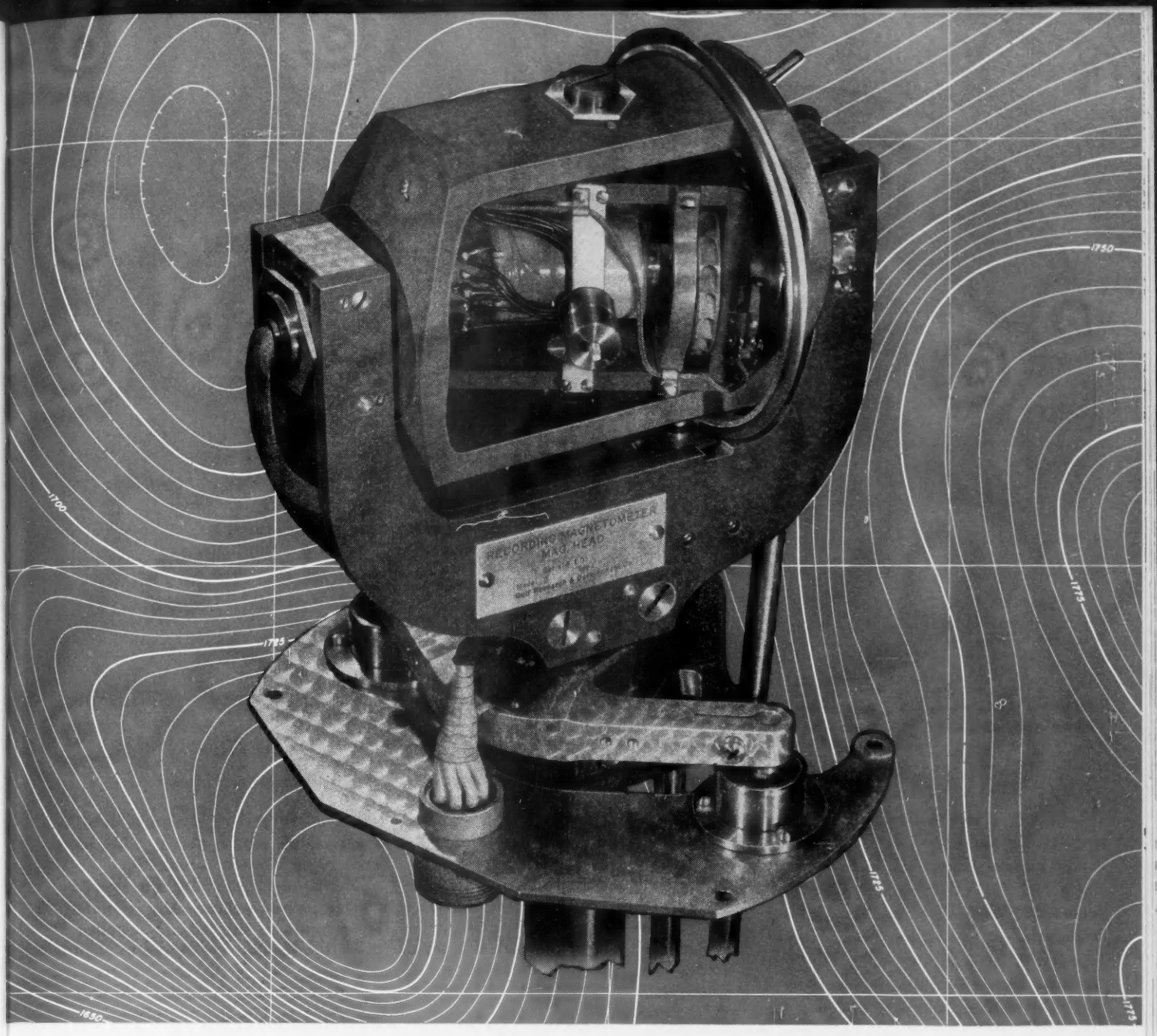


FIGURE 2. Pre-Des Moines Paleo-outcrop map

■ CONTINUED ON PAGE 60



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PLASTIC TUBES Simplify Core-Handling and Storage

By GILBERT M. WILSON, Staff Writer

FIGURE 1. Cores which are to be kept for special handling or long storage may be permanently sealed by simple application of a special solvent prior to closing tuble with red plastic cover.
Photos Courtesy Extruders, Inc.

CLEAR plastic tubes designed expressly for the safe handling, shipping or permanent storage of oil well cores have become available to oil operators, geologists and core analysis service companies. Supplied in increments of one-fourth-inch, in any size, from one to three inches in diameter, including a 1⅜ x 7-inch tube especially designed for sidewall cores, these light, easily-handled tubes now make it possible for an operator to preserve cores indefinitely and in perfect condition, from the time they are removed from the core barrel until the time they are examined in the office or laboratory. Developed and manufactured by a West Coast plastic firm, the tubes are extruded in any lengths desired. The material is clear or opaque as desired, and is water- oil- and gas-proof.

Specially fabricated, close-fitting caps of plastic material are used to close the ends of the tubes. One cap of clear plastic is installed at the factory and becomes a permanent part of the tube. The other cap of red plastic, which is supplied with the tube, is installed in the field. For average purposes, the snug-fitting cap applied in the field may be all that is required to preserve the cores for later examination. If desired, the cap may be taped to the tube, using adhesive-type or common electrician's tape. However, if a core is to be preserved for special handling or kept for an indefinite length of time, the field-installed cap may be sealed, a special solvent which is applied with a brush (Figure 1) being available for this purpose. Sealed in this manner, the tube becomes air tight. If the core is from a "no-dope" hole, it may be sealed in an opaque black tube available for that particular purpose.

Identification of cores in the plastic tubes is simple. The tubes permit the driller or tool pusher to identify immediately and preserve the cores in their original condition and proper sequence. The geologist thus assured that cores will be preserved in perfect condition until he arrives at the well, is able to cover more wells in an allotted period.

Danger of accidentally mixing or reversing cores is practically eliminated through use of the red cap installed at the well which always serves to identify the upper end of the core. There is a definite advantage in having the bottom cap made of clear plastic, for an identifying label or tag, dropped into the bottom of the tube before the core is inserted, provides a positive means of identifying that particular tube. When the geologist is searching for a particular core which is laid down or "filed"

FIGURE 2. When a section of core is removed from a tube, a capped spacer of equivalent length may be inserted in its place and the whole then re-assembled. Identity, date and disposition of section removed is written on label placed within the spacer.

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among others in a case or storage rack, the identifying tag visible from the outside speeds processing of the core record.

Examination of cores, after they have been sealed in the tubes, may be done in a number of ways. For a quick preliminary examination of the core, the geologist may find it sufficient merely to examine it from the outside, having the advantage of being able to pick up the container and view the contents from all sides. For closer inspection or analyses, pieces of core may be removed through slits cut in the tube opposite the intervals of special interest, the openings then being closed and re-sealed with another piece of plastic cemented on with the plastic solvent. If an entire section of the core is to be removed, the desired portion is taken out, after which a capped spacer—a length of plastic tubing of smaller diameter than the original tube—may be inserted in its place and the whole then re-assembled. The plastic tube substitute may be tagged to identify the particular section removed, and to indicate its subsequent disposition, Figure 2 shows a section of tubing thus identified.

Because the tubes are tamper-proof, important gas- and fluid-content analyses may be made at any time after the core has been taken. For future re-checking of samples taken from passed-up formations or abandoned wells, availability of such cores becomes valuable. Instead of having to be content with sealed cans or breakable glass jars, either of which may hold only a small part of a complete core in each container, the geologist may preserve an entire core. Being unbreakable, the tubes will withstand possible rough handling on the derrick floor and subsequent transporting to the office. Shipping of cores to distant points, particularly in the case of overseas operations, becomes possible with a minimum of wrapping, crating or special handling.

Carrying Cases

To facilitate the carrying, shipping or filing of core tubes, a rectangular carrying case was introduced. Constructed of flat strips of stainless steel, the case weighs only 14 pounds. Ten inches square by 37 inches long, the container will hold nine 2x36-inch tubes. Bottom and top of the case are held in place by coiled tension springs, and are easily removed. Matching holes drilled through the case and covers permit locking of the unit to prevent unauthorized removal or tampering with the core tubes.

A light weight, clear plastic cylindrical container designed to hold 14 of the 1⅜ by 7-inch sidewall core tubes recently was made available. Measuring five inches in diameter by 15 inches in length, it is equipped with a strong plastic carrying handle. It is available also in a 30-inch length to permit carrying twice as many cores as the smaller container. Similar to the above is another carrying case which recently was developed for the handling and transporting of the 5⅝-inch diamond drill bit cores.

Some companies are finding that certain sizes of the tubes make ideal containers for the shipping of water and oil samples.

World's Deepest Well Bore

■ CONTINUED FROM PAGE 56

Lindsay-Bradley-Chitwood east-west trending wedge of structurally high pre-Deese features.

Problems of Classification

Probably the most significant aspect of this deep test and its bearing upon the historical geologic events that created the Arbuckle-Wichita Mountain system and the adjacent Anadarko Basin are the implications in regard to the relative age of orogenic movements in the Mid-Continent compared to those assumed to exist elsewhere in the world. Ever since Chamberlain, some 40 years ago, advanced the concept of world-wide and simultaneous mountain building, such writers as Bucher, Stille, Schuchert and others have attempted to sub-divide the geological column for the world on the basis of a concept of periodic, widespread diastrophism. One of the more prominent of these was supposed to separate the Pennsylvanian from the Mississippian system, not only in North America, but particularly in Europe where Stille set the age of the great Sudetic epoch of folding at the Mississippian-Pennsylvanian boundary, asserting that this corresponded with the Wichita and Ouachita epoch of folding in the Mid-Continent of North America and with orogenic movement in other parts of the world. But the evidence in the thicker sequences of the Mid-Continent indicates that any late Mississippian movement was of negligible consequence compared to the two early Pennsylvanian intervals of mountain building that occurred just preceding and following Atoka time and initiated the southern Oklahoma structural system.

Subdivision of the Carboniferous. Whereas much precedent has been established, especially by students of European stratigraphy, for the grouping of certain later Paleozoic rocks into one system of Carboniferous age, it has become desirable, in regions such as the Appalachian geosyncline and the Mid-Continent province of North America where thousands of feet of Carboniferous rocks were deposited, to subdivide these, not only into mappable units for convenient correlation, but where the evidence is so plain as to the interrupting influence of major mountain building movements, the American decision to set-off thick genetic units of systemic rank seems justified.

Thus, in parts of the Anadarko Basin, we deal with about 3000 feet of Mississippian rocks, 13,000 to 14,000 feet of Pennsylvanian, and about 5000 feet of Permian beds (which are a marginal facies of the thicker Permian Basin sequence of West Texas). However, within this long sequence, the intervals of orogenic activity do not correlate with the late Mississippian diastrophism of the Appalachian geosyncline, which involved truncation of the Chester series and the subsequent onlap of the early Pennsylvanian, Pottsville series. Instead, deposition in southern Oklahoma continued without significant interruption until late Morrow pre-Atoka orogenic movements were initiated. Whether or not we will eventually be able to prove that such orogenic movements were progressive in time and direction or were simply restricted to geologic provinces of independent geologic history, at any rate we are obliged to define systemic and series boundaries upon faunal and floral criteria to salvage any utility from the precedent-bound world chronology.

Value of deep tests. The cumulative effect of late Paleozoic movements in southern Oklahoma was to depress the basement rocks approximately 30,000 feet below the present position of pre-Cambrian granite exposures a few miles south in fault-blocks of the Wichita Mountains in a structural system of great magnitude and complexity that must be mapped largely on inferences deduced from the record of deep tests.

This article covers part of an extended research program undertaken by Dr. Robert R. Wheeler in an effort to interpret the accumulating stratigraphic and structural evidence bearing upon Anadarko Basin oil possibilities. Contributions to date include papers on Basin *Tectonics* (Geol. Soc. Amer., 1945), *Elmore Embayment* (Amer. Assoc. Petrol. Geol., 1946), *Geology and Oil Possibilities* (World Oil, 1947-48) and *Deepest Well* (XVIIIth Intern. Geol. Congr., 1948). Under his direction newly organized study groups of the Oklahoma City Geological Society are engaged in detailed studies of strategic Basin problems.

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Exploration

Up 16 Percent in 1948

By CECIL SMITH, Staff Writer

THE search for new sources of oil and gas was carried on by the industry in 1948 on a considerably larger scale than in any previous year. In 1948 more than 6800 exploratory wells were completed to out-distance the previous high drilled in 1947 by more than 16 percent. Although this record-breaking exploration failed by a small margin to equal last year's producing well-to-dry hole ratio, its results in actual number of successful ventures were considerably better.

Exploratory wells drilled in 1948 totaled 6827, an increased of 61.2 percent over the previous peak of 5874 completed in 1947. Of these ventures, 1347 were commercially productive in 1948 for a 19.7 percent average, while last year's 1242 amounted to a slightly better 21.1 percent of the total. However, the big difference in the two years' records was the increase in new sources of oil found in 1948.

New oil pools opened in the past year totaled 884, an increase of 164 or 20.1 percent over the 736 found in the previous year. These new discoveries include 601 new fields and 283 new pay horizons in established fields. In 1947 the

Summary of Results of Exploratory Drilling

ITEM	Dec., 1948	Nov., 1948	TWELVE MONTHS Jan.-Dec. 1948	1947	Percent Diff.
Oil Discoveries	82	68	884	736	+ 20.1
New Fields	55	52	601	436	+ 37.8
New Pays	27	16	283	300	— 5.7
Distillate Discoveries	18	12	115	98	+ 17.3
New Fields	9	11	70	44	+ 59.1
New Pays	9	1	45	54	— 16.7
Gas Discoveries	15	8	140	145	— 3.4
New Fields	13	6	103	96	+ 7.3
New Pays	2	2	37	49	— 24.5
Total Discoveries	115	88	1,139	979	+ 16.3
Extensions to Fields	14	12	208	263	— 20.9
Oil Fields	11	8	166	169	— 1.8
Distillate Fields	2	2	18	17	+ 5.9
Gas Fields	1	2	24	77	— 68.8
Total Prod. Tests	129	100	1,347	1,242	+ 8.5
Dry Holes	496	485	5,480	4,632	+ 18.3
Wildcats	494	479	5,408	4,407	+ 22.7
New Pays			11	59	— 81.4
Outposts	2	6	61	166	— 63.3
Total Expl'tory Tests	625	585	6,827	5,874	+ 16.2
Percent Productive	20.6	17.1	19.7	21.1	
Percent Dry	79.4	82.9	80.3	78.9	

Results of Exploratory Drilling in December and Year, 1948-47, by Districts

State or District	MONTH OF DECEMBER, 1948													YEAR, 1948																
	Productive Tests										Unproductive Tests				Productive Tests									Unproductive Tests					Total Exploratory Tests	
	New Fields			New Pays			Extensions			Total Productive				Total Exploratory Tests	New Fields			New Pays			Extensions			Total Productive		Wildcats	New Pays	Outposts	Total Dry			
	Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas		Wildcats	New Pays	Outposts		Oil	Dis.	Gas	Oil	Dis.	Gas	Oil	Dis.	Gas	12 Mo. 1948	12 Mo. 1947				12 Mo. 1948	12 Mo. 1947	12 Mo. 1948	12 Mo. 1947
Alabama											1			1												20			20	24	20	24
Arizona																										1			1	3	1	3
Arkansas											7			7	7			1						8	12	105			105	74	113	86
California	2		1	1			5			9	10			19	17		2	8			30	1	1	59	32	197	1		198	269	257	301
Colorado		1	1							2	4			6	2	1	2	1					2	8	7	50			50	44	58	51
Florida											1			1												23			23	27	23	27
Georgia																										3			3	5	3	5
Illinois	5			1			2			8	60			68	28			25		1	42			96	144	555			555	440	651	584
Indiana	4			1						5	19			24	32		1	5			7			45	25	277		1	278	135	323	160
Iowa																																
Kansas	4		1				1			6	48			54	66		7	3			5			81	73	479	1		480	344	561	417
Kentucky	1						1			2	3			5	6		1	1			2			10	49	52			52	152	62	201
Louisiana				3	1			1		5	18			23	21	18	7	43	15	2	4	5	3	118	88	242		1	243	275	361	363
North Louisiana					1					1	11			12	7	3	4	2	2		3	2	1	24	17	132			132	190	156	207
South Louisiana				3				1		4	7			11	14	15	3	41	13	2	1	3	2	94	71	110		1	111	85	205	156
Maryland																										1			1		1	
Michigan	2		1							3	30			33	13		5	2			3			23	21	253			253	238	276	259
Mississippi											10			10	3	1					2	1		7	12	113		2	115	88	122	100
Missouri											2			2												23			23	18	23	18
Montana			1							1				1	3		1	1			1			6	6	32		1	33	21	39	27
Nebraska																														2		2
Nevada																																
New Mexico	1									1	16			17	10	1	2	5		1				19	13	90			90	66	109	79
New York																									2					18		20
North Carolina																														5		5
Ohio							1		1	2	1			3	1		1				2		10	14	12	37			37	43	51	55
Oklahoma	4	3	2	2			1	1		13	36			49	61	6	18	25		1	5	1		117	107	444		2	446	531	563	638
Oregon																														1		1
Pennsylvania																									48	4			4	75	4	123
South Dakota																										1			1	2	1	2
Tennessee															2									2	2	35			35	23	37	25
Texas	31	5	5	18	8	2				69	218		2	289	312	43	44	147	30	32	59	9	8	684	538	2270	8	52	2330	1615	3014	2153
Dist. 1 S. Central	2									2	19			21	10			1		1				12	14	191		1	192	144	204	158
Dist. 2 Middle Gulf	2	2	2		3					9	15			24	14	11	9	16	11	7	4	6	1	79	63	176	1	9	186	123	265	186
Dist. 3 Upper Gulf	1	1	1	5	2	1				12	21			33	18	13	5	56	8	11	8	2	4	125	81	265	3	4	272	187	397	268
Dist. 4 L. Gulf-SW	2	1	2	7	3					15	40		2	57	28	13	9	29	11	12	6	1	2	111	122	332	1	24	357	275	468	397
Dist. 5 E. Central											6			6	4			2			1			7	12	88			88	76	95	88
Dist. 6 Northeast											9			9	6	3	1	5			5			20	18	68	2		70	61	90	79
Dist. 7-B N. Central	12			2		1				15	33			48	95	1	12	18		1	5			132	73	421		1	422	257	554	330
Dist. 7-C W. Central	4									4	6			10	21		1	2			2			26	26	89		1	90	43	116	69
Dist. 8 West	4			2						6	20			26	58		5	6			17		1	87	63	182	1	8	191	137	278	200
Dist. 9 North	4			2						6	49			55	57	2	1	12			11			83	64	452		4	456	290	539	354
Dist. 10 Panhandle															1		1							2	2	6			6	22	8	24
Utah															2		3							5		13			13	9	18	9
Virginia																	1							1	3					3	1	6
Washington											1			1												3			3	7	3	7
West Virginia																	4							4	19	4			4	25	8	44
Wyoming	1		1	1						3	9			12	15		4	16			4	1		40	29	81	1	2	84	50	124	79
Total U. S.	55	9	13	27	9	2	11	2	1	129	494		2	625	601	70	103	283	45	37	166	18	24	1347	1242	5408	11	61	5480	4632	6827	5874

Excerpt from Lane-Wells operator's report:

"In this field, most of the production comes from the Arbuckle dolomite, often from very thin zones. Measurements only slightly in error can, therefore, cause serious difficulty, especially as some of the porous zones in the Arbuckle contain nothing but water.

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breakdown was 436 new oil fields and 300 new pay strata. The difference in the total new oil fields for the two years was an increase of 37.8 percent for 1948, while the number of new pay horizons represented a drop of 5.7 percent for the year just completed.

New distillate discoveries for the year also showed an increase over the 1947 record. New distillate fields opened numbered 70 compared with 44 a year ago. New pay strata in existing distillate fields totaled 45 against last year's 54.

Natural gas discoveries totaled practically the same for the two periods, with 1948 being credited with 140 and the previous year with 145. However, the more recent period had an increase in the number of new fields found, but some decrease in the new pays. New fields numbered 103 for 1948 against 96 for a year ago and new gas pays amounted to only 37 compared to 49 in 1947.

Extensions to established fields are also included in the above exploratory well figures and in this category the year 1948 showed a 20 percent decline when compared with the preceding year. In 1947, wells that were successful in extending field production by at least one-half mile totaled 263, while last year's 208 amounted to 20.9 percent less.

Of the 6827 exploratory wells completed in 1948, there were 6182 classed as rank or strict wildcats, and of these 774 were rated as commercial producers.

New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in December, 1948

Also Important Extensions to Established Fields.

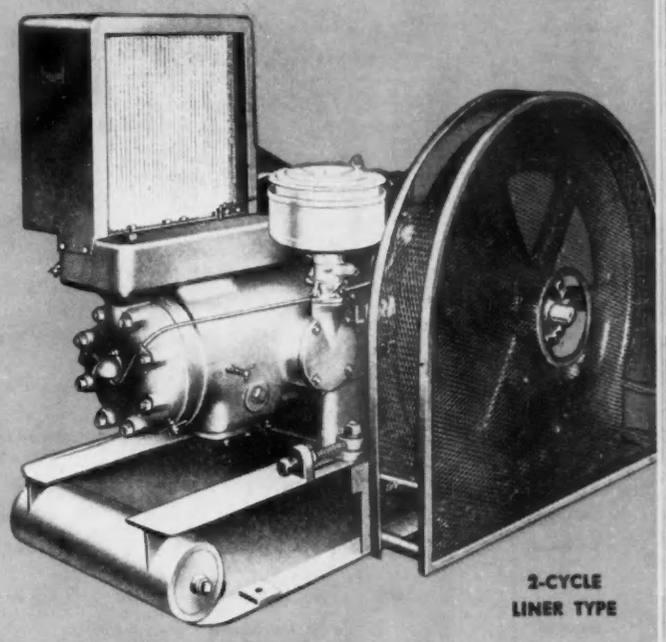
COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		CALIFORNIA—New Oil Fields						
Kern	Edison, S.	Beloil Corp's Lawson-Bennett 45-26-1, 330 s&w fr e Sect. 26-30s-29e	12-27-48	2958	2729- 2956		F 200; 1/4"	26
Kern		Hancock Oil Co's KCL 85-23, 350 s&w fr e1/4 cor. Sect 23-30s-26e, Gosford area, 2½ mi ne Ten Section fld.	12-12-48	8476	7839- 7854	Stevens sd; Mio	F 236; 11/64"	34.7
		CALIFORNIA—New Oil Pay						
Kern	Lost Hills	Standard of Calif's Cahn 59, 190 s 2446 e fr nwc Sect. 9-27s-21e	12- 8-48	5300	3597-		F 26; 33 wtr; 1/2"	21.8
		CALIFORNIA—Oil Field Extensions						
Fresno	Guijarral Hills	Barnsdall Oil Co's Allison 84-34-1, Sect 34-20s-16e, ½ mi n extension	12-27-48	8773	8717- 8741	Leda sd; Olig.	F 280; 1/4"	37.9
Kern	Devils Den	Gilliland Oil Co's Logan-Green 1, Sect 10-25s-18e, nw extension	12-10-48	650	530- 650	U. Temblor sd; Mio	P 52; 98 wtr	15.8
Kern	Mountain View	Hogan Pet. Co's Symons-Bankline 6, 990 n 660 w fr s1/4 cor Sect 4-31s-29e, s extension.	12-11-48	6967	6035- 6080	Sta Margarita sd; Mio	F 337; 74 wtr	32.5
Los Angeles	Aliso Canyon	Standard of California's Frew 1-6, Sect 29-3n-16w, sw extension	12-14-48	8758	8585- 8752		P 318	20.7
Fresno	Jacalitos	Union Oil Co's Son Fee 85-20, Sect 20-21s-15e, w extension	12-10-48	3569	3504- 3568	U. Temblor sd; Mio	F 365; 1/16"	
		CALIFORNIA—New Gas Field						
Yolo		Shell Oil Co's Unit 3-1, 400 n 900 e fr swc Sect. 8-8n-1w, Pleasant Creek area, 5 mi w Winters fld.	12-22-48	3000	2784- 2820		4.2 mln, 3/8"	
		COLORADO—New Distillate Field						
Montezuma		Western Nat'l & Byrd-Frost & P. B. English's Anna Driscoll 1, cn1/2 ne nw Sect 3-38n-19w, Dove Creek structure.	12-20-48	8286	5910- 5934	Paradox li; Penn	F 438; 5.5 mln 1/4"	68
		COLORADO—New Gas Field						
Routt		General Pet. Co's Gov't 55-34, nw nw se 34-4n-99w, Pagoda Anticline	11-29-48	4900	3957- 4037	Shinarump sd; Tri	7.7 mln	
		ILLINOIS—New Oil Fields						
Christian	Assumption, N	Nat'l Assoc. Pet. Co's J. H. Lawrence 1, se ne se 9-13n-1e, 3 mi n Assumption fld.	12-21-48	2310	2285- 2304	Devonian li; Devo	P 116	
Clay	Riffle	J. L. Black & Central Pipe Line's Hammer 1, sw ne sw 5-4n-6e, 2½ mi fr production.	12- 7-48	2763	2736- 2744	Rosiclare li; Miss	P 200	
Jefferson	Williams	H. E. Howard's A. R. McLaughlin 1, nw se sw 2-3s-2e, 2½ mi w Mt. Vernon fld.	12-31-48	2796	2574- 2578	Aux Vases sd; Miss	P 12; 68 wtr	
Perry	Craig	Nat'l Assoc. Pet. Co's J. A. Ernest 1, n ne ne 23-4s-4w, 10 mi fr prod	12-14-48	3735	3640- 3685	Trenton li; Ord	P 22	
Wayne	Zenith	Gulf Ref. Co's W. S. Rush 1, ne ne ne 35-2n-5e, 3½ mi fr prod	12-21-48	2983	2970- 2974	McClosky li; Miss	P 92	
		ILLINOIS—New Oil Pay						
Wabash	New Harmony-Keensburg Cons.	G. Sourapas' J. Hocking 4, sw sw ne 20-2s-13w	12- 7-48	2604	1339- 1345	Bridgeport sd; Penn	P 10	
		ILLINOIS—Oil Field Extensions						
Hamilton	Dahlgren	R. Bartmes' Whipple 1, nw nw sw 23-3s-5e, ¾ mi n extension	12-14-48	3382	3292- 3304	McClosky li; Miss	P 144	
Wayne	Bennington	Arvin Drlg. Co's Hubble 1, se sw nw 13-1n-9e, ¾ mi sw extension	12-14-48	3151	3138- 3151	Aux Vases sd; Miss	P 100	
		INDIANA—New Oil Fields						
Huntington	Warren	Stanley H. Vegars' Clifford Jones 1, 330 fr s&wl nw nw nw 17-26n-10e	11-10-48	1006	984- 1006	Trenton li; Ord	P 30	
Randolph		V & S Oil Co's Ray Arnold 1, 165 fr s&wl nw sw ne 7-21n-13e, Green twp.	11-10-48	947			P 20	
Vanderburgh		A. B. Potter's Robt. Mahrenholz 1, se sw nw 16-7s-11w, 1 mi sw Cypress fld.	12-17-48	1651	1648- 1651	Waltersburg sd; U Miss	P 65	
Vigo		Princeton Mining Co's Henry P. Smith 1, 330 fr n&el ne ne ne 15-11n-9w	11- 3-48	2933	1664- 1750	Devonian li; Devo	P 90	
		INDIANA—New Oil Pay						
Posey	College	Basin Drlg. Co's Oakland City College 1, nw ne se 16-8s-14w	12-28-48	1856	1852- 1856	Waltersburg sd; U Miss	P 30	
		KANSAS—New Oil Fields						
Barton	Bryant	Alpine Oil & Royalty Co's Bryant 1, nw sw ne 27-20s-12w, 1 mi ne Workman fld.	12- 7-48	3405	3383- 3405	Arbuckle li; Ord	P 171	
Barton	Hiss, SE	Ben F. Brack's Wright 1, ne ne sw 32-20s-13w, 1 mi se Hiss pl.	12-16-48	3561	3545- 3561	Arbuckle li; Ord	P 190	
Rooks		W. L. Hartman's Westhusin 1, sw sw sw 31-9s-17w, 4 mi se Paradise Creek fld.	12-21-48	3615	3477- 3488	Lansing sd; Penn	P 12	
Russell	Parker	Skelly Oil Co's Parker 1, se se nw 18-15s-12w, 1 mi w Hall-Gurney pl.	12-22-48	3270	3259- 3270	Arbuckle li; Ord	P 23	
		KANSAS—Oil Field Extension						
Pratt	Chance	Deep Rock et al's Calbeck 1, sw sw ne 33-26s-13w, ½ mi n extension	12- 7-48	4441	4342- 4435	Arbuckle li; Ord	P 50	
		KANSAS—New Gas Field						
Johnson		G. L. Smith's Pretz 1, sw se nw 1-14s-22e, 2 mi ne Gardner pl.	12-14-48	1560	652		0.5 mln	
		KENTUCKY—New Oil Field						
Union		A. D. Falletti & B. Turner's Geo Randolph 1, 1560 fr sl 1770 fr wl of Sect 17-P-20, 1 mi e Uniontown fld.	12-29-48	2348	2325- 2336	Cypress sd; Penn	P 68	
		KENTUCKY—Oil Field Extension						
Daviess	Stanley	F. M. Ashby's St. Peter Catholic Church Ld. 1, Sect 5-P-28, 1½ mi e Stanley, ½ mi ne extension	12-29-48	998	973- 998	Palestine sd; U Miss	P 152	
		NORTH LOUISIANA—New Distillate Pay						
Webster	Shongaloo	Stanolind & Continental's Mitchell 1, e ne se 31-23n-9w	12- 8-48	11295	10301-10328	Cotton Valley sd; Jur	F 312; 2.3 mln; 1/4"	55.6
		SOUTH LOUISIANA—New Oil Pays						
Calcasieu	Iowa	Magnolia Pet. Co's E. L. Scott 1, Sect 18-9s-8w, on e side of prod.	12-28-48	11506	8710- 8714		P 100	38.4
Iberia	Weeks Island	Shell Oil Co's J. A. Smith 1-A, Sect 18-14s-7e	11-26-48	15094	14243-14255		F 420; 1/4"	33
Jefferson	Grand Isle	Humble O&R Co's Grand Isle State Lse, Acct. 2, No. 3, Blk 18, Tr. 1116, Gulf of Mexico.	12-14-48	9424	9221- 9236		F 518; 5/32"	35.7
		SOUTH LOUISIANA—Distillate Field Extension						
Jeff Davis	Jennings, S.	Stanolind O&G Co's So. Jennings Unit 9, Sect 11-10s-3w, n extension	12- 2-48	11271	9636- 9646	Miocene	F 60; 2.3 mln; 1/2"	52
		MICHIGAN—New Oil Fields						
Arenac	Standish	Frank E. Roush's Angus 1, se se ne 10-18n-4e, Lincoln twp.	12-24-48	4111	4111	Richfield sd; Devo	P 30	
Muskegon		Muskegon Development Co's Hazel Grove School Dist. 1, ne ne nw 9-12n-15w, Holton twp.	12-24-48	1994	1992- 1994	Traverse li; Devo	P 30; 30 wtr	

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formations abbreviated thus: Plio, pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hr. rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.

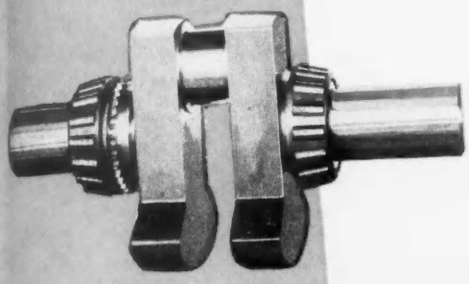
Types "L" and "O" "Oilwell"-Lorain Engines

...are adaptable to a wide range of oil-field applications

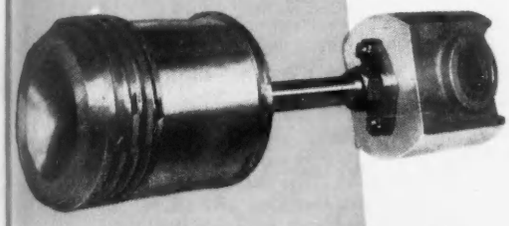


2-CYCLE LINER TYPE

Outstanding Features

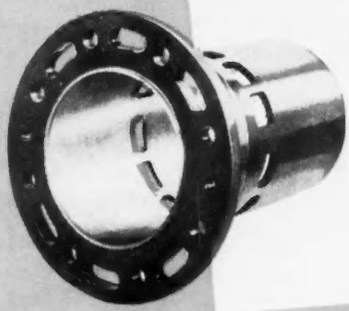


FORGED-STEEL CRANKSHAFT is mounted in heavy-duty tapered-roller bearings. Crankshaft is counterweighted to reduce torsional stress and bearing pressures. The large diameter crankshaft is machined to carry the pilot bearing for the clutch power take-off.



PISTON—Precision-ground piston is fitted with five rings assuring high compression, easy starting, and maximum power for continuous service. The flanged piston rod is bolted to both the crosshead and piston, thus permitting easy removal of piston for maintenance and service in the field.

CONNECTING ROD of the automotive type is drop-forged from alloy steel and heat-treated. It has a reinforced I-beam section with solid eye for crosshead pin and bushing. Connecting-rod cap is held in place by heat-treated, body-fitted bolts. The crank pin bearing is a replaceable, shim-adjusted bronze backed babbit lined shell.



CYLINDER LINER is a wet-sleeve type and is made from alloy cast-iron to assure long life. It is quickly and easily replaced on location; eliminating costly reboring jobs, minimizing down-time, and maintaining standard dimensions.

THE "OILWELL"-Lorain Type "L" and Type "O" Engines are heavy-duty, single cylinder, two-cycle power units, built to withstand continuous service with minimum attention.

They have (1) condenser-type cooling system, (2) large capacity oil reservoir, (3) oil-bath splash lubrication for crankshaft and bearings with mechanical force-feed lubricator supplying positive lubrication to the liner and piston—all contributing to effective lubrication.

These engines are sturdy, compact and weatherproof, and can be equipped to operate on either natural gas or butane—and are convertible to cold-start Diesel engines.

BRIEF SPECIFICATIONS

"Oilwell"-Lorain Engine	Type "L"	Type "O"
Bore and Stroke ..... inches	7½ x 8	9½ x 10
R. P. M.	600	450
Horsepower	21.4	32
Mean Effective Pressure.....p.s.i.	40	40

Same Ratings for Gas or Diesel Fuel

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USS "OILWELL"

UNITED STATES STEEL

New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in December, 1948—(Continued)

Also Important Extensions to Established Fields.

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		MICHIGAN—New Gas Field						
Missaukee		Sohio Pet. Co's State-Caldwell 1, c nw 30-23n-8w, Caldwell twp	12-28-48	1167	1112- 1159	(Michigan) Stray sd; Miss	0.9 mln	
		MONTANA—New Gas Field						
Golden Valley		The Texas Co's Northern Pacific "D" 1, c sw sw 31-5n-20e, Big Coulee-Hailstone dome.	11- 2-48	4581	1905- 2070	Morrison sd; Jur	0.1 mln	
		NEW MEXICO—New Oil Field						
Lea		Continental Oil Co et al's Warren Unit 1-B-29, 1980 fr s&el Sect 29-20s-38e, 1½ mi e Skaggs pl.	12-15-48	9070	8947- 9070	McKee sd; Ord	F 3528; 1"	40
		OHIO—Oil Field Extension						
Perry	Lancaster	Foraker Drlg Co's F. C. Henderson 1, ne se Lot 18, Hopewell Twp., 1 mi s Glenford Village.	12-24-48	2831	2786- 2806	Clinton sd; Sil	F 86	
		OHIO—Gas Field Extension						
Lorain	Ashland	Ohio Fuel Gas Co's E. L. Pierce 1, Lot 10 Penfield Twp., 1 mi n Penfield Village.	12-10-48	2528	2438- 2456	Clinton sd; Sil	0.4 mln	
		OKLAHOMA—New Oil Fields						
Jefferson	N. Ringling	Amerada Pet. Co's Edwards 1, nw se se 4-4s-4w	12-23-48	3152	2724- 2784	Pennsylvanian sd; Penn	P 212	34
Noble		H E R Drlg.'s T. E. Dolezal 1, nw sw se 11-20n-1w	12-23-48	5047	4772- 4777	Peru sd; Penn	P 5	
Okfuskee		Falcon Seaboard's Palmer 1, ne nw nw 13-13n-8e	12-28-48	3436	3420- 3436	Union Valley-Cromwell sd; Penn	P 112; 112 wtr	39
Pottawatomie		Earl Sadler's Gaddy 1, nw nw se 21-10n-2e, 1½ mi se Shawnee Lake, W. pl.	12-23-48	6078	5986- 5998	1st Wilcox sd; Ord	F 270; ¼"	37.8
		OKLAHOMA—New Oil Pays						
Seminole	Bowlegs	Earl Sadler's Miller 1, se se sw 18-8n-7e	12-28-48	4212	3995- 4018	Hunton li; Devo	F 110; ¼"	
Stephens	Alma, N	J. E. Crosbie, Inc & Warren Oil Corp's Pickens 2, se ne nc 9-1s-4w	12-25-48	5709	4940- 4980	Pennsylvanian sd; Penn	P 210	34
		OKLAHOMA—Oil Field Extension						
Garvin	Maysville, SW	California Co's K. Graham 1, ne ne sw 36-4n-3w, sw extension	12-16-48	7698	7550- 7554	Bromide sd; Ord	F 113; ¼"	43
		OKLAHOMA—New Distillate Fields						
Garvin		Texas Co's Donham 1, ne ne nw 22-4n-3w	12-28-48	8045	6773- 6785	Pennsylvanian sd; Penn	F 70; ½"	55
McClain	Goldsby, SW	Danciger O&R Co's De Cordova 1, nw se sw 35-8n-3w	12- 2-48	9383	9373- 9376	Bromide sd; Ord	F 514; 5.7 mln; 21/64"	65
Stephens	Marlow, SE	Tide Water et al's South Marlow Unit 1, c se sw 27-2n-7w	12-28-48	11575	7902- 7910	Pennsylvanian sd; Penn	F 370; 8 mln	59
		OKLAHOMA—Distillate Field Extension						
Beckham	Elk City	Union Prod. Co's G. G. Music 1, c n½ se nw 25-10n-21w, 2 mi se extension	12-23-48	9708	9639- 9662	Granite Wash; Penn	F 237; 2.9 mln	63
		OKLAHOMA—New Gas Fields						
Caddo		Denver Prod. & Ref. Co's School Land "A" 1, c se sw 16-10n-9w	12-16-48	17094	12600-12660 15400-15510	Pennsylvanian sd; Penn Vicla li; Ord	5 mln	
Stephens		Phillips Pet. Co's Jennett 1, se se nw 25-2s-7w	12-30-48	2939	2643- 2800	Lime	71.2 mln	
		TEXAS—District 1 (SOUTH CENTRAL)—New Oil Fields						
Atascosa	"Poteet"	McFarland Drlg. Co's Henrietta Krisch et al 2, 3600 fr nel 1500 fr nwl of Sur. 1207, 3 mi n Poteet.	12- 8-48	3612	3570-.....- 3612	Anacacho li; U Cre Austin ch; U Cre	F 128; ¼"	41.4
Frio	"Doering"	Humble O&R Co's Frank Doering 1, 1320 fr swl 660 fr nwl Blk 4, D. D. Harrigan's Leona Valley Fms. Subdn, Oscar Crawford Sur., 5 mi sw Pearsall fld.	12-24-48	6645	5512- 5776	Austin ch; U Cre	P 73	26
		TEXAS—District 2 (MIDDLE GULF COAST)—New Oil Fields						
Calhoun	"Melbourn"	Southern Prod. Co. Inc.'s W. C. Melbourn 1, 330 fr se&swl Blk 4, Burton & Hoover Subdn. Benito Morales Sur. 6½ mi s-se Port Lavaca.	12-12-48	10009	8587- 8597	L Frio sd; Olig	F 134; 4/16"	45.5
Goliad		Hassie Hunt Tr's Ollie Webb 1, 660 fr el 1320 fr sl 1295-ac lse, Maria de Jesus Ybarbo Gr. 3 mi ne Charco.	12-30-48	7898	4208- 4214 7272- 7282	Pettus sd; Eoc Slick sd; Eoc	F 113; 1/8" no gge (Dist.)	47.3
		TEXAS—District 2 (MIDDLE GULF COAST)—New Distillate Fields						
Goliad	"Irby"	Amerada Pet. Corp's R. F. Irby 1, Maria de Jesus Ybarbo Gr., 9 mi w of Goliad.	11-20-48	9756	9242- 9248		F 61; 2.3 mln; 5/32"	49.2
Live Oak	"Tom Lyne"	Atlantic Ref. Co's T. J. Lyne 1, 1870 fr nel 3960 fr sel Jacob Cook Sur, 1 mi n-nw Clay West Field.	11-15-48	10000	9230- 9260		no gge	
		TEXAS—District 2 (MIDDLE GULF COAST)—New Distillate Pays						
Goliad	Gottschalt	W. L. Goldston's Mary Meyer 1-A, St. Luke de Mott Sur, also ⅔ mi sw extension.	12- 2-48	8960	8947- 8970		30 mln; open	
Live Oak	Harris	Continental Oil Co's Frank C. Goodwin 3-A, Jacob Matson Sur.	12-24-48	9608	9074- 9120		F 23; 0.4 mln; open	49
Victoria	Keeran	Gulf Oil Corp's G. Keeran et al 20, Martin de Leon Gr	12-18-48	7748	6622- 6624		F 68; 0.9 mln; 4/32"	37.9
		TEXAS—District 2 (MIDDLE GULF COAST)—New Gas Fields						
Lavaca		Grubb & Hawkin's S. A. Clark 1, 467 fr n&el J. H. Clayton Sur, 4 mi w-sw Provident City fld.	12-10-48	5833	1650- 1670		1.3 mln; ¼"	
Victoria		Woodley Pet Co's Geo A. Musselman 1, 1320 fr nw&swl W. W. Nichols Sur, 1 mi se "Salem" fld.	11-20-48	5502	2266- 2276		3.2 mln; open	
		TEXAS—District 3 (UPPER GULF COAST)—New Oil Field						
Hardin		Gulf Oil Corp's Richard Teel Est. 1-A, Thomas C. Gaines Sur, 1½ mi off sw flank of Saratoga Dome.	12- 9-48	5119	4446- 4460		F 101; 8/64"	36.7
		TEXAS—District 3 (UPPER GULF COAST)—New Oil Pays						
Brazoria	W. Columbia	Gulf Oil Corp's Mrs. M. L. Mayes et al 11, 169-42-ac lse, George Tennille Lge.	12-17-48	7350	6590- 6627		F 129; 11/64"	29.1
Fort Bend	Blue Ridge	Swiss Oil Co's Davison 1-B, (OWWO), J. Pointevent Sur, e flank of dome	12-16-48	4082	4092-		P 45	44
Galveston	High Island, N. Flank	Placid Oil Co's Robert & Mueller (Island) 1, 904.25-ac lse, John Grogan Sur.	12-29-48	7637	7321- 7328		F 184; 4/16"	38.2
Harris	Un-named	F. M. Corzelius' H. H. Rath 1, Wm. Sevey Sur, Geo. W. Harbin Sbdn	11-11-48	7800	7089- 7094		F 15; 3/16"	38.6
Liberty	N. Dayton	The Texas Co's John A. Deering et al NCT-1-I, 1215-56-ac lse, Sect 135, H&TC Sur.	12-31-48	3168	2700- 2710	Frio sd; Olig	F 145; 11/64"	39.2
		TEXAS—District 3 (UPPER GULF COAST)—New Distillate Fields						
Brazoria		Gulf Oil Corp's S. S. Perry et al 1, Stephen F. Austin Lge. 7 mi se of Brazoria, Peach Point area.	12-17-48	12984	11278-11348		F 50; 10.5 mln	55
Wharton		Hassie Hunt, Tr.'s J. W. Prasifka 1, (OWDD) 465.88-ac lse, S. A. Larche Sur. & Joseph Clements Sur. 2½ mi se Prasifka gas fld.	12-10-48	7515	5809- 5815		F 10; 1.5 mln; 3/32"	55
		TEXAS—District 3 (UPPER GULF COAST)—New Distillate Pays						
Chambers	Mayes, E	Humble O&R Co's East Mayes Gas Unit 1, 314.68-ac lse, E. H. R. Wallis Sur. ½ mi w of prod.	11-30-48	10000	8850- 8853	Frio sd; Olig	F 257; 5.4 mln; ¼"	58.2
Liberty	Cottonwood	William Helis' Hirsch Est. 4, 1120-ac lse, T&NO Sur, Sect 17	11-15-48	8200	7943- 7954	Hackberry sd; Olig	F 84; 1.2 mln; 3/32"	46.5
		TEXAS—District 3 (UPPER GULF COAST)—New Gas Field						
Wharton		Hunt Oil Co's Edwin Hawes Jr. 1, 660 fr nw&nel of 186-ac tr. Randall Jones & Martin Allen Sur, 1½ mi e of Wharton.	12-10-48	6517	5199- 5202		1.3 mln; 3/32"	
		TEXAS—District 3 (UPPER GULF COAST)—New Gas Pay						
Brazoria	Damon Mound	The Texas Co's Continental Oil Co Fee 1, E. S. Jones Sur, 1030 fr el of lse & Sur, 149.7 fr nl of lse, 1 mi off se flank of Damon Mound.	12-28-48	4110	3966- 3974		2.3 mln; open	
		TEXAS—District 4 (LOWER GULF-SW)—New Oil Fields						
Brooks	Palo Blanco	Geo. H. Echol's Mrs. Donal Alexander 1, 3500 fr nl 3228 fr wl Share 1-B of Las Megueyes de Palo Blanco Gr.	12-15-48	3616	3607- 3612		F 121; 4/32"	40.8
Kenedy	"Rita"	Humble O&R Co's S. K. East 1, 12,300 fr sl 17,535 fr wl Los Finados Gr., 16 mi s-sw of Sarita.	12-28-48	11282	7076- 7084		F 270; 4/16"	43
		TEXAS—District 4 (LOWER GULF-SW)—New Oil Pays						
Aransas	Fulton Beach	Wm. H. Hunt Trust Est.'s Spencer-Kent-Crane 4, (OWDD) 720-ac lse, C. O. D. Gilliland Sur.	12- 8-48	8994	7484- 7489		F 164; 11/64"	42.3

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formations abbreviated thus: Plio, pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hr. rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.

Cemented?

SURE... BUT IS THAT WATER *Really* SHUT OFF?

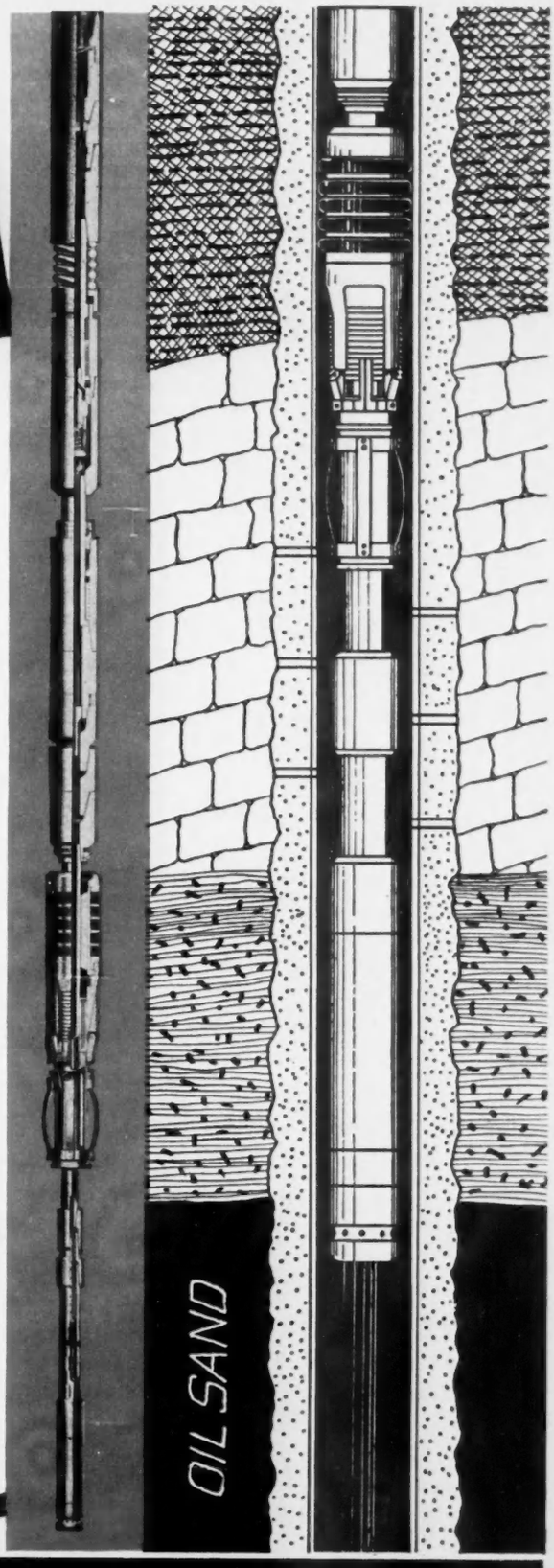
A Johnston water shut-off test will answer that question . . . and it may prevent the loss of your well while it's doing it.

To see how, let's first take a look at a well completed *without* a water shut-off test. Casing has been perforated opposite the producing zone in the conventional manner and water . . . too much water . . . is being produced with the oil. Knowing that the lower part of your sand contained water, you figure that's where it's coming from, so you squeeze and re-shoot higher. But you're still getting water, so you squeeze and perforate again . . . and again . . . and again. If you're lucky, you finally get a shut-off and make a well, but you've contaminated your oil sand so badly through those successive squeeze jobs opposite it that it's a pretty weak one. On the other hand, cement contamination may have completely ruined the sand or, perhaps, you *never* get a shut-off and abandon the well as a salt-water producer.

Now let's see what a Johnston water shut-off test would do for the same well. First, instead of perforating *opposite* the producing zone, you perforate *above* it with four or six shots. Then, into the hole with a Johnston Tester and when that water shows up, you *know* it's not coming from the producing zone at all . . . *it's coming from upper water sands that were never shut off by the original cement job.* So you squeeze, and because you're up close to the trouble zone, your chances of success the first time are much greater. Even if you have to squeeze several times *you never contaminate your oil sand* because you're squeezing through perforations well above it. When you do make a well, it's just as good as original tests indicated it would be.

To protect your investment, make a Johnston water shut-off test on every well *before you perforate the producing zone.* Costs are negligible when compared to the risk taken when they're not made.

Full information may be obtained from any Johnston representative at points listed below.



SHOOT-N-TEST on one run. Johnston Testers can be run in combination with the Johnston Hydrostatically Actuated Gun Perforator, so that you perforate and test on one run of the drill pipe.

Pressure Recorders on Johnston Testers provide accurate records of bottom hole flowing and shut-in pressures. From these records, a true interpretation of well characteristics may be made.

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FORMATION AND CASING TESTING
JOHNSTON

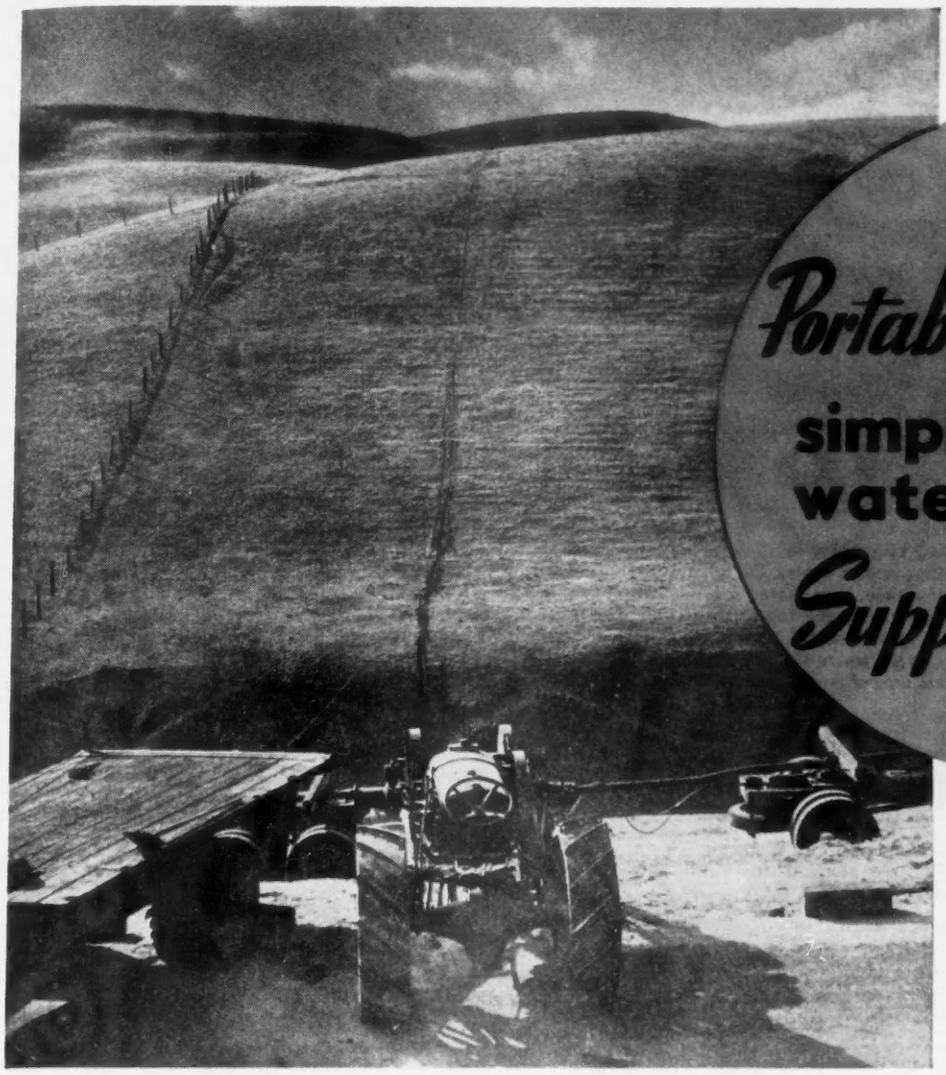
New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in December, 1948—(Continued)

Also Important Extensions to Established Fields.

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
Duval	Fitzsimmons, N.	Transwestern Royalty Co's Cristin Solis 1, 113.75-ac lse, J. Poitevent Sur.	12- 4-48	4469	4428- 4438		P 46	44
Jim Wells	Seeligson	Sunray Oil Corp's Judge E. Wilson 3, Sect 49, Haldeman Subdn. W. C. Dickson Sur.	12-30-48	8930	6527- 6533	Zone 20-G	F 157	42.8
Kenedy	Sarita	Humble O&R Co's John G. Kenedy, Jr., 3-B, (OWWO), GC&SF Sur. El Paistle Gr.	12-17-48	10342	4611- 4621		P 76; 19 wtr; 1/8"	37.4
Kenedy	Sarita	Humble O&R Co's John G. Kenedy, Jr., 6-B, GC&SF Sur., El Paistle Gr., 3½ mi ne Sarita.	12-20-48	8838	6967- 6973		no gge	....
Nueces	Minnie Bock, N.	Atlantic Ref. Co's A. C. Gandy 1, Sect 54, G. H. Paul Subdn. of Driscoll Reh, Joaquin Lopez de Herrera Sur.	12-30-48	8206	7006- 7012		F 14; open	33.1
Starr	Borosa	Continental Oil Co's Dee Davenport et al 6, 942.16-ac lse, ½ mi s-se of prod.	12-30-48	4784	4706- 4716		F 166; 4/16"	48.2
		TEXAS—District 4 (LOWER GULF-SW)—New Distillate Field						
Brooks	"Santa Fe"	Humble O&R Co's Santa Fe Ranch 1, 22,163-ac lse, San Salvador de Tule Gr., 6½ mi se Encino.	12-24-48	9005	3237- 3242		F 22; 1.3 mln; 1/8"	34
		TEXAS—District 4 (LOWER GULF-SW)—New Distillate Pays						
Brooks	Gyp Hill	Sun Oil Co's J. E. Hensley 1, 159.82-ac lse, L. B. Wright Sur 332	12- 8-48	7493	7283- 7305		F 25; 1.6 mln; 1/4"	....
Hidalgo	Cecil	Coastal Refineries, Inc. & M. L. Massingill's Garcia Ld & Livestock Co. 1-B, 80-ac "B" lse, in Porc. 42.	11-25-48	6510	5928- 5933		F 28; 4 mln; open	53
Nueces	Agua Dulce	Puenticitas Oil Co's Simmonds & Perry (Fee) 40-B, Sect 8, Simmonds & Perry Subdn. Puenticitas Sur.	10-15-48	7400	6916- 6948		F 121; 40 mln; open	....
		TEXAS—District 4 (LOWER GULF-SW)—New Gas Fields						
Brooks		Humble O&R Co's Robert J. Kleberg, Jr., Tr. 2, Los Muertos Pasture, 5280 fr wl 6600 fr sl La Noria de Tio Ayola Gr. 1½ mi e Boedeker gas fld.	12-20-48	7923	1860- 1870		2.2 mln; open	....
Starr		The Texas Co's Samuel D. Bloomberg et al 1, 660 fr n&el Xavier Zamora Porc. 41, 1474.28-ac lse.	12- 2-48	10011	8855- 8880		0.7 mln	....
		TEXAS—District 7-B (NORTH CENTRAL)—New Oil Fields						
Brown		R. H. Kimsey et al's W. P. Thomas 1, 2300 fr wl 4100 fr sl Wm. B. Travis Sur. 148, 1 mi s Cross Cut.	7-10-48	1366	1348- 1359		P 10	38
Brown		Pioneer O&G Co. Inc's J. L. Richardson 1, 450 fr sl 1050 fr wl SA&MGRR Sur., 4 mi nw Brownwood.	12-18-48	1950	1473- 1478	Caddo li; Penn	P 12	....
Brown		United North & South Dev. Co's A. J. Wheeler 1, 1120 fr nl 330 fr el of 320-ac lse, B. W. Garvin Sur 2, 4 mi w May.	11-30-48	2886	2710- 2735	Ellenburger li; Ord	F 26; 3/8"	....
Eastland		Brakeen Prod. Co's W. B. White 1, 1300 fr nl 330 fr wl of A. Kent Sur. 6 mi s Carbon.	12-18-48	2880	2734- 2750	Marble Falls li; Penn	F 8; 1/4"	38.5
Fisher	"Roby"	Lion Oil Co & Exploration Drlg. Co's Hale 1, 330 fr n&el of Sect 27, Blk 317, El Paso CSL Sur, 2 mi n Longworth.	11-20-48	3541	3529- 3541	Flippen li; Penn	F 140; 1/4"	37.6
Jones		Thos. D. Humphrey's Annetta Lee Gray 1, 1650 fr sl 330 fr wl of sw¼ of Sect 25, DLDA Sur, 2 mi sw Avoca.	12- 2-48	2122	2110- 2122	King sd; Penn	F 147; 11/64"	38.7
Shackelford		Dick Schwab's Chloe Nail 1, 330 fr n&el of sw¼ of Sect 123, ETRR Sur, 12 mi nw Albany.	12-12-48	5302	4954- 4966		F 187; 21/64"	44
Stephens		Kadane Griffith Oil Co's Frazell "A" 1, 467 fr n&wl of nw½ of Sect 23, Blk 8, T&PRR Sur, 12 mi e Albany.	12-27-48	4454	.....		F 206; 11/64"	42
Throck-morton		Fred M. Manning Inc's L. C. Atkinson "H" 1, 1400 n 400 w of nec, F. A. Richardson Sur, 4 mi se Throckmorton.	12-19-48	4755	4725- 4755	Mississippi li; Miss	F 160; 1/4"	....
Throck-morton		Fred M. Manning Inc's Cathy-McNutt Unit 1, 100 fr nl 450 fr el of w½ of Sect 225, BBB&CRR Sur, 3 mi sw Throckmorton.	12-26-48	4987	.....		P 30	42
Throck-morton		Woodley Pet Co's J. L. Edens 1, 881 fr nl 279 fr el of 435-ac lse, Sect 689, TE&L Sur, 1 mi ne Odell Deep fld.	12-28-48	4574	4568- 4574	Mississippi li; Miss	P 40	41
Young		R. C. Lipscomb's Furr & Allar 1, 1800 fr nl 400 fr wl of Sect 316, TE&L Sur, 2¼ mi n Padgitt-Miss. fld.	12-21-48	4771	4756- 4771	Chappell sd; Miss	F 259; 7/32"	42
		TEXAS—District 7-B (NORTH CENTRAL)—New Oil Pays						
Throck-morton	Morrison (Strawn)	M. A. Grisham's Arlene Gregory 1, 362 fr nl 1200 fr wl of Sect 1193, TE&L Sur, south of production.	12- 5-48	4720	4675- 4715	Mississippi li; Miss	F 475	42
Throck-morton	Throckmorton Co. Reg.	Humble O&R Co's Kirk Ledbetter 3, Sect 2, W. S. Riddle Sur	12-27-48	4566	4549- 4553	Marble Falls cgl; Penn	F 1462; 4/16"	41
		TEXAS—District 7-B (NORTH CENTRAL)—New Gas Pay						
Wise	Chico	Kingwood Oil Co's S. H. Curtner 2, C. W. Egery Sur	12-17-48	5997	5777- 5799		4.3 mln; open	....
		TEXAS—District 7-C (WEST CENTRAL)—New Oil Fields						
Schleicher		Skelly Oil Co's Mary L. Jackson 1, 1650 fr nl 2310 fr wl of Sect 41, Blk LL, 3 mi nw of El Dorado.	12-16-48	4109	4073- 4091	Canyon li; Penn	F 207; 1/2"	32
Tom Green		Placid Oil Co's L. T. & L. C. Clark 1, 660 fr s&el Sect 2, HE&WT Sur, 6 mi w of Water Valley.	11-21-48	7838	1035- 1045	San Andres li; Perm	P 43	35
Tom Green		Plymouth Oil Co's J. Wiley Green 1, 1980 fr n&el Sect 193, Dist 11, SPRR Sur, 15 mi se San Angelo.	12-16-48	4754	4724- 4754	Strawn li; Penn	F 362; 1/2"	36.2
Upton	"Wilshire"	Wilshire Oil Co's McElroy Ranch Co. 23-148, 660 s&w of c of Sect 148, Blk E, CCSD&RGNG Sur, 5 mi e McElroy pl.	12- 9-48	13977	7740- 7980	Wolfcamp li; Perm	P 227	36.8
		TEXAS—District 8 (WEST)—New Oil Fields						
Andrews		Champlin Ref. Co's University 1-F, 660 fr s&el Sect 34, Blk 12, Univ. Lds. Sur., 1 mi n Parker W. fld.	12-11-48	8700	7137- 7167	Clear Fork sd; Perm	P 80	42.7
Andrews		Stanclind O&G Co's Frank Cowden 1, 660 fr s&wl Sect 3, Blk 43, T-1-N, T&P Sur, midway betw Emma & N. Cowden flds.	12-24-48	5183	5148- 5183	Holt li; Perm	F 311; 1/4"	34
Hockley		Edward C. Lawson's Geo. L. White 1, 440 fr s&el Lab 16, Lge. 704, Taylor CSL Sur.	12-22-48	4648	4617- 4645		P 94	31.9
Pecos	Abell-Silurian	Magnolia Pet Co's J. W. Lutz 2, 648 fr sl 673 fr wl Lot 5, Sect 27, Blk 9, H&GN Sur.	8-25-48	4946	4936- 4944	Montoya li; U Ord	F 163; 3/32"	39.7
		TEXAS—District 8 (WEST)—New Oil Pays						
Andrews	Nelson	Humble O&R Co's H. O. Sims et al 3, Sect 25, Blk A-39, PSL Sur	12-21-48	10685	7160- 7190	Wichita-Albany sd; Perm	P 42; 9 wtr	34.7
Andrews	Shafter Lake	Sinclair Prairie Oil Co's University 2-154, Sect 24, Blk 13, Univ Lds. Sur.	12- 4-48	11898	11685-11760	Ellenburger dolo; Ord	F 1,140; open	42.9
		TEXAS—District 9 (NORTH)—New Oil Fields						
Archer		Fain & McGaha & Republic's W. C. Priebe 1, 330 fr e&nl of Sect 2, Blk 1, HXTC Sur, 2 mi s Vogtsberger fld.	12-16-48	4755	4685- 4701		P 105	41
Montague		Continental Oil Co's H. A. Richardson 1, 467 fr s wl 560 fr nwl of Blk 79, Titus CSL Sur, 1½ mi s Mueller fld.	12-31-48	6570	6054- 6073	Bend cgl; Penn	F 1,000; 1/2"	42
Young		Hanlon-Boyle, Inc's K. D. Oates 1, 1320 fr nl 330 fr wl Sect 1672, TE&L Sur, 1½ mi ne Hanlon fld.	12- 9-48	2912	2906- 2912	Strawn sd; Penn	F 192; 1/4"	41
Young	"Gabby"	Hunter Bros' Mrs. Emma Wiechman, 467 fr n&wl of Sect 173, TE&L Sur, 2 mi nw Olney.	12-30-48	4370	4345- 4355	Caddo li; Penn	F 216; 1/4"	41
		TEXAS—District 9 (NORTH)—New Oil Pays						
Young	Young Co.	Lipscomb & De Lange's W. T. Swink "A" 1, 1150 fr nl 400 fr wl of Sect 301, TE&L Sur, 10 mi sw Olney.	12- 3-48	4989	4956- 4970	Mississippi li; Miss	F 118; 1/8"	42
Wilbarger	Odell	Humble O&R Co's Morgan-Berry 4, Sect 5, Blk 11, H&TC Sur	12-21-48	6574	6474- 6574	Ellenburger li; Ord	F 216; 1/2"	44.7
		WYOMING—New Oil Field						
Hot Springs		Stanclind & Ohio's L U. Sheep 1, se sw nw 25-46n-100w, Enos Creek structure.	12-20-48	7139	6365- 6488	Tensleep sd; Penn	P 200	....
		WYOMING—New Oil Pay						
Natrona	W. Poison Spider	Pure Oil Co's Unit 2, c nw nw 11-33n-84w, ¾ mi nw of production	12-30-48	9288	9230- 9288	Mesa Verde sd; U Cre	F 709; 3/8"	45
		WYOMING—New Gas Field						
Park		Continental Oil Co's Gov't 1, ne ne ne 8-57n-98w	12-13-48	6306	2810- 2840	2nd Frontier sd; U Cre	2.9 mln; 5/8"	....

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formations abbreviated thus: Plio, pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hr. rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.



Portable Pipe Lines simplify Wildcat water and fuel Supply Problems

By GILBERT M. WILSON
Staff Writer

FIGURE 1. A 15,000-foot water line was laid across this type of terrain by dragging 1000-foot lengths of pipe by winch and tractor across ravines and steep slopes. Working from ridge tops where the sections were joined together, the pipe line was rapidly laid and as easily taken up after the well was drilled.

A SERVICE OPERATION, apart from the drilling company equipment, provides water and gas piping to the wildcat on a rental basis, taking over the responsibility and providing water and/or fuel by the time the rig is set up. Drilling company personnel is reduced, and service company men utilize full time on multiple contracts, thus aiding contractors in reducing over-all drilling costs.

LAYING a 15,000-foot temporary pipe line by dragging it in 1000-foot lengths over hills and across steep ravines.

Trucking, stringing and laying ten miles of three-inch pipe over rough ground by one crew in ten days total time.

Those are but routine accomplishments in the pipe line rental business of a large supply company in Bakersfield, Calif.

For a number of years this company has been supplying rental pipe lines to oil companies and drilling contractors to bring water and fuel into remote wildcat locations in the San Joaquin Valley and coastal regions of California. Light weight, grooved end, quick-coupling type pipe in 2-, 3-, and 4-inch sizes is most commonly used in such lines. Joints are made up in 40-foot lengths . . . two 20-foot lengths welded together . . . to speed handling and making up in the field.

A typical job, performed by a crew of five men, consists of leaving the yard at Bakersfield in the morning with 5000 to 6000 feet of pipe, trucking it out to the job (which may be anywhere from 25 to 100 miles distant) stringing the pipe, making up couplings, setting up a portable pump if needed, and returning to the yard the same evening. Equipment employed on the average field job usually consists of a truck and trailer for hauling pipe to the job, and a four-wheel drive converted Army vehicle, the latter being equipped with a small boom and front-end winch as well as pipe carrying racks mounted above the fenders on each side. While five men ordinarily make up the crew on the average job, four men usually handle stringing jobs in flat or easily accessible terrain.

Among the more difficult jobs recently handled was a 15,000-foot water line of three-inch pipe which had to be laid over very rough, semi-mountainous terrain (Figure 1). Working from ridge tops, and with the aid of truck winch

FIGURE 2. Generally better results are obtained by pushing sections of the pipe over the brow of a hill rather than pulling it with cables. On the job shown above several joints were made up at a time, then shoved over the edge by the truck, which shuttled back and forth on the top of the ridge. The slope in this instance was so steep, approximately 40 to 45 degrees off vertical, that the driver was unable to see where the line was going. Two men guided the lower end of the line around trees, rocks and brush.

FIGURE 3. Pipe in 40-foot lengths, two 20-foot lengths welded together, is trucked to the field as far as possible, then transferred to the four-wheel drive field truck which then strings the pipe along the right-of-way or dumps it at ridge tops if the line is to be made up into sections. Equipped with front end winch, light boom and pipe-carrying racks, this unit traverses slopes that are difficult even for men to climb afoot. It is freqeuntly used to break trail through heavy brush so men can work on the line.

and an anchored tractor, 1000-foot sections were made up and pulled over hills and across steep gullies and canyons, the line swaying like a rubber band until it was pulled over and laid on the ground. Despite the terrific strain on pipe and couplings, gaskets and joints held and the line performed satisfactorily.

Lines Shoved Over

Recent experience has shown, however, that better results generally are obtained by pushing sections over a slope rather than pulling them. In such an operation, the truck unloads the pipe at the crest of the hill and sections containing from ten to 25 joints are made up and shoved over. The boom-equipped truck picks up the short string in the middle, or takes up a position at the far end of the line, whichever is more expedient, and pushes the line over the edge. Figure 2 shows the truck in the process of shoving a string over a ridge so steep and covered with brush that the men on top were unable to see where their string was running, being forced to rely on shouted instructions from the men guiding the lower end of the line.

Under more favorable conditions, where slopes are not as steep, the pushing operation is easier. The truck driver can see what is going on below and can govern the speed of the truck accordingly as he shuttles back and forth over the crest of the hill. One or two men at the lower end of the line guide their end down the slope, carrying it around trees, through brush and over slight hummocks. Pushing the line is considered less harmful to the pipe couplings for the pipe ends abut each other with resulting less chance of injury to gaskets in the couplings.

When lines must be laid through areas so remote or heavily brush-covered that the pipe hauling truck is unable to go all the way, a central transfer point is set up and pipe is unloaded and placed on the four-wheel drive truck (Figure 3). This unit, which is capable of carrying from five to nine joints on each side, then takes it on to the right-of-way, stringing it as on the route or dumping it at ridge top, depending upon how it is to be laid. It is not infrequent that on a job in rough country slopes encountered are so steep that the field truck is forced to use not only its four wheel drive, but also a winch line anchored to a stump at the top of the hill. The versatility of the unit is further shown through its being used to break trail through heavy brush and undergrowth to enable men to work. Figure 4 illustrates a typical job where men and equipment are forced to work on unusually steep slopes.

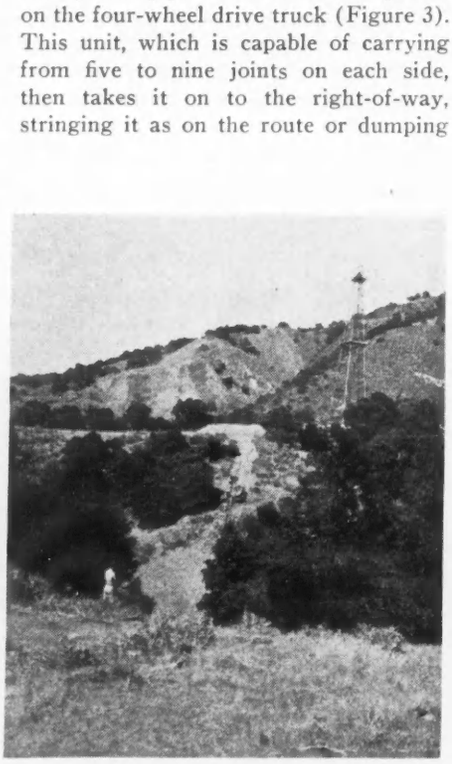


FIGURE 4. This view illustrates conditions found on a typical job involving running a three-inch water line to a remote wildcat well in the coastal region of the state. Making their own road and stringing pipe as they go along, the crew, with the aid of the four-wheel drive truck, make short work of this part of the job. Photograph does not show extreme bottom of the steep sided ravine being traversed.

One of the longest rental lines laid was a 15-mile, 3-inch, 300-pounds per square inch gas line in the vicinity of Stockton, Calif. Another high pressure line, this one carrying water at 750 pounds pressure, was nine miles long, extending from the bottom of Elkhorn Valley, near Taft, half way up into the Temblor Range, an unusually rugged terrain. In 1948 a ten-mile gas line was laid in the Buena Vista Lake area to deliver fuel gas to a wildcat well. This line was laid in ten days, including the time required to load pipe in the yard, deliver it out to the job, lay it, and make the necessary tie-in connections, all done by a single crew. In almost every job of this type, wherever feasible, a pipe line is laid across country in as straight a line as possible. Although this often involves more off-the-road transportation difficulties, the men and equipment employed are trained and capable of doing the work, and as a consequence, less pipe, and less field time are required on a given job. In Figure 5 is shown the typical operation of making up a connection in the field.

A large job currently being handled is

the supplying of water to each of the some dozen drilling rigs developing the holdings of a major company in the recently discovered Cuyama oil field. Here, about 100,000 feet of three-inch line is in constant use, the pipe being taken up from completed wells and relaid to new locations. Water is pumped from a nearby river and is distributed to the drilling wells. The pipe line service includes connecting into the water supply and hooking up to the tanks at the location, enabling the rig to have ample water on hand the very first day it is moved on to the well.

One of the more serious of the occupational hazards sustained by the field men, outside of the normal difficulties daily encountered in the routine handling of pipe on steep slopes and rought terrain, is rattlesnakes. This hazard is not so great when the pipe is first laid, but when the line is to be taken up, it becomes a different story. Particularly during hot summer days and in the more arid parts of the country, snakes crawl up beside the cool water lines to escape the heat.

Moderate Charges for Service

Charges for the rental service are based on a flat rate of 10 cents per foot for the average line over one mile in length. Lines under that length rent for 12 cents per foot. Where unusually difficult conditions are encountered, slightly higher rates apply. This rental charge includes the hauling, laying, use of the line for 90 days, and taking up the line afterward. When a string is returned to the yard, it is thoroughly checked (Figure 6), gaskets and fittings renewed wherever needed, and made ready for the next job. For the oil operator or drilling contractor, this contract-type arrangement generally is far cheaper than he could own, maintain and lay his own line. This is particularly evident when such items as hauling, repairing and acquiring of additional crews just for the job are considered. In addition, losses suffered when pipe lines lie idle on the racks between wells requiring such installations, also must be considered.

Also available on a rental basis are small portable, skid-mounted power pumps. These units are taken out and set up ready for service on the line at any convenient water hole, well or locally available municipal system. A typical unit of this type (Figure 7) consists of a 4x6 duplex pump driven by V-belts from a 12-horsepower multicylinder gasoline engine. With proper speed reduction, the unit is capable of supplying water at about 800 pounds per square inch pressure.

A new feature to be added shortly to the pipe line rental service is 150-barrel capacity water tanks that can be set up quickly. These tanks, to be mounted on skid bases, will be high and relatively slim. They will be hauled to the field in a horizontal position on the same trucks that carry the pipe. Built of 3/16-inch steel, the tanks will be constructed in sections to facilitate replacement in the event of damage. Spoke-like internal reinforcing will be built into each tank to enable it better to withstand the rough service to which it will be subjected during repeated hauling and setting up operations. Tank fittings will be the quick-coupling type to permit speedy connecting up to the portable pipe lines.

That this portable pipe line service is popular among oil operators in the area is attested by the fact that frequently as much as 325,000 feet of pipe may be out on rental at any one time. The small amount of equipment that is employed, or that can be used due to the nature of the typical topography traversed, speaks well for the ability and ingenuity of the pipeliners on the job.

FIGURE 5. Typical operation of making up a connection in the field. This consists of installing the gasket, placing over it the two halves of the coupling, and spinning down the two nuts with any convenient type of speed wrench.

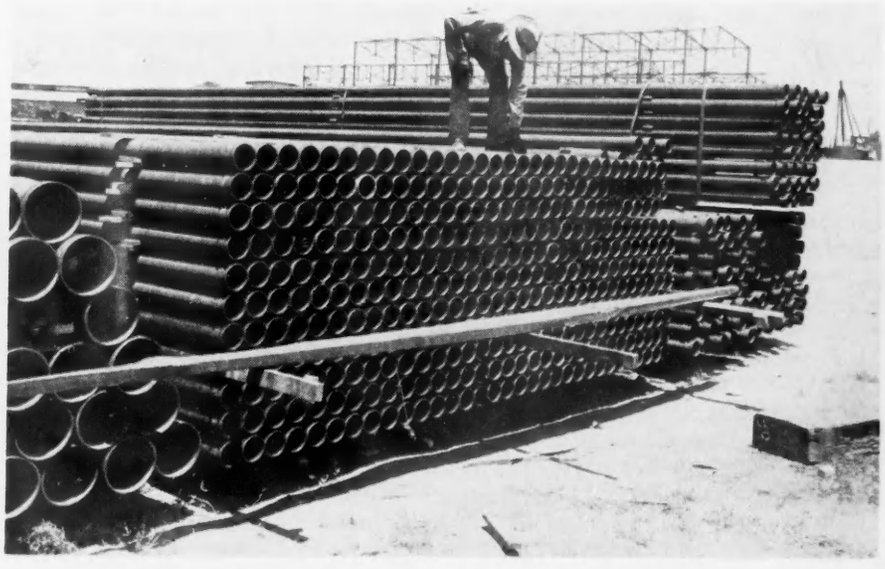


FIGURE 6. When a line is taken up and returned to the yard, individual joints, couplings and gaskets are thoroughly checked, and if necessary, repaired or replaced before being sent out again. Here a workman is inspecting a rack of pipe containing about two miles of the approximately 60 miles of pipe that frequently is out on rental at one time.

FIGURE 7. Also available on rental basis are small portable gasoline engine driven power pumps. Such units are set up beside any convenient stream or well and connected into the line ready for service. Clam shovel is shown digging sump hole for pump. Steep ridge in background is slope down which pipe was shoved during operations pictured in Figure 2.

Cost Investigation on Water-Loss Reduction

By GORDON M. GRAHAM
Petroleum Engineer

IT WOULD BE of inestimable value to an engineer and operator if a method were available whereby well conditions could be accurately simulated in advance. Such a method is discussed and demonstrated in this article, which describes how the foregoing can be accomplished using laboratory equipment to simulate field conditions and applying the results to low water-loss drilling fluids.

WITHIN the past ten years the demand for petroleum products has increased so greatly that oil reserves located at moderate and shallow depths, easily accessible and less expensive to develop than deeper production, have been depleted. Oil companies have found it necessary to drill to greater depths in search of additional supplies of oil in order to maintain their reserves. In the same period, drilling costs have increased considerably, both as a result of increase in depth, and as a result of an over-all increase in the cost of equipment, materials, and labor. Consequently, more and more attention is being devoted to cost considerations for all factors influencing drilling operations.

In rotary drilling, the engineering involved in the transmission of the correct drilling fluid in and out of the hole under the widely varying conditions experienced in drilling, the effect of this fluid on the formations penetrated, the efficiency of the drilling operation, and the ultimate production of the oil reservoir are paramount considerations in determining the break-even cost for conducting deep drilling and production.

In order to reduce costs for deep operations, the role of the drilling fluid must be considered. It is essential that the drilling fluid be evaluated to determine its suitability for the conditions to be expected; the drilling fluid be considered in relation to the effect achieved; and the most efficient and economical drilling fluid program possible be developed for a particular well or field.

In the following discussion, a method is demonstrated whereby the foregoing may be accomplished, using laboratory equipment to simulate field conditions, and applying the results to one phase of drilling fluid engineering, namely, low water-loss drilling fluids.

Low Water-Loss Drilling Fluids

In attempting to design a drilling fluid, tailored to the specifications and requirements of each well or field the drilling fluid engineer is confronted with the task of adjusting the drilling fluid to develop the most desirable property or properties to achieve the most economically made and maintained fluid, the one which will permit the most rapid rate of drilling, and the one which will be most satisfactory for completing the well.

Chief among the desirable properties of a drilling fluid is a low water-loss and thin filter cake deposition.

In penetrating formations above the pay horizon, a low water-loss drilling fluid is desirable to prevent (1) excessive enlargement of hole diameter in soluble formations such as salt zones; (2) hydration of bentonitic shale causing caving or heaving and ensuing drilling and completion difficulties; and (3) decreased hole diameter due to deposition of thick filter cake incidental to high water-loss which in turn may result in difficulties.

Through both field experience and laboratory research, it has been conclusively proved that water lost to the pay formations during completion operations is undesirable. Water-blocking, reduction in permeability, necessity of swabbing, washing down, scraping and other completion practices raising the cost of completing the well, together with permanent damage to the pay formations in many cases and reduction in ultimate production of the well, can result from use of a high water-loss drilling fluid.

In seeking to reduce the detrimental effect of water lost from the drilling fluid during drilling and completion, engineers and operators have applied many techniques and practices. The practice which has yielded the most satisfactory results has been the addition of some agent to the drilling fluid to improve the water-loss properties. Such an agent must be reasonably effective in lowering the water loss when added in small concentrations, must not impair the properties of the drilling fluid beyond control, must be chemically stable under temperatures encountered during drilling, must have no corrosive action on equipment, and must be cheaply and easily obtained and capable of being stored, mixed and handled with a minimum amount of technical supervision.

The addition of gelatinized starch, sodium carboxymethylcellulose, and oil-base stock to native clay or processed bentonite drilling fluids are three of the agents which have received the widest application in reducing water-loss.

First to be employed to any extent, and now widely used in many areas, starch drilling fluids are adaptable to a broad range of drilling conditions, can be rather easily controlled with common oilfield chemicals, and with the proper supervision, will produce very satisfactory low water losses. Some method of preventing fermentation of the starch must be employed.

Emulsion drilling fluids, consisting of a clay-water fluid in which an oil-base stock is emulsified, achieve the effect of producing a low water loss, but are not so widely adaptable to all drilling conditions. In addition, under some circum-

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stances, difficulty in viscosity control and foaming have been noted.

Drilling fluids to which sodium carboxymethylcellulose is added to effect a reduction in water-loss have proved to be exceptionally successful under almost all drilling conditions encountered. Although such fluids have not yet received as widespread a field usage as starch and emulsion drilling fluids because of their more recent development, high cost of the sodium carboxymethylcellulose, and limited supply, indications are that these drilling fluids will be more widely used in the future.

Evaluation of Low Water-Loss Drilling Fluids

In evaluating a low water-loss drilling fluid, i.e., in attempting to establish the fact that the one under consideration is superior and cheaper to some other one, or to forecast that one type will be superior to and cheaper than another type for a particular well or drilling problem, the evaluator is confronted with the problem of translating the experience or knowledge derived from the behavior of the drilling fluid in one well and under one set of conditions to applications in another well. It is a rare situation when two wells will present the same drilling problems throughout the drilling operations, and even more rare when the same conditions will persist from one field to another. Obviously, once the well is drilled, it is impossible to go back and employ a drilling fluid program different from the one originally followed. It is apparent, then, that it would be of inestimable value to the engineer and operator if a method were available whereby well conditions could be accurately simulated in advance. Behavior of the drilling fluid under anticipated conditions could be studied, and an estimate of the cost of the proposed drilling fluid program could be secured.

Considerable effort has been expended to arrive at a system of evaluation based on simple physical tests of the drilling fluid during the conduct of the drilling operations, and several investigations have been made to determine criteria which could be applied to evaluate low water-loss drilling fluids.

Results of investigations have shown that many factors must be considered:

1. The drilling fluid should be in constant circulation during the course of the investigation, as would be the case during drilling operations, and it should be arranged so that circulation can be stopped or started for any period of time, as would occur when drilling operations are suspended or resumed.
2. It should be possible to subject the fluid to increasing temperature during circulation to simulate increasing temperature with depth.
3. A rapid means of checking the viscosity of the fluid, without withdrawing fluid from the system and allowing it to cool, should be available.
4. The water-loss and filter cake test should be conducted at temperatures and pressure differentials encountered in well conditions.
5. Prior to the addition of the water-loss reducing agents, the fluid used should have constant properties for comparative tests of the effects of the agents.
6. The property being studied (in this case, water-loss) may vary, while other properties of the fluid such as density, viscosity, etc., should be controlled within a pre-determined range, such as would be necessary under field conditions.
7. With the exception of the water-loss reducing agents, materials added to control viscosity, density, or other properties, should be the same kind.

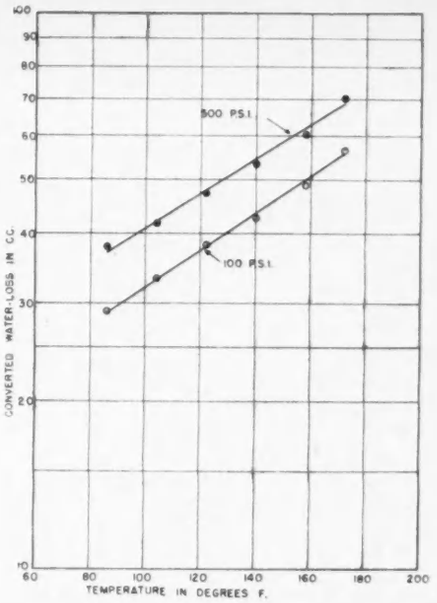


FIGURE 1. Effect of temperature on water-loss McKittrick clay-water fluid.

In previous investigations involving evaluation of low water-loss drilling fluids, all of the above factors have apparently not been considered, nor has an evaluation system been employed whereby a cost comparison to effect a given water-loss reduction could be made.

Bearing in mind the factors necessary to compare the evaluation of low water-loss drilling fluid systems, the following program was adopted:

1. Employment of an apparatus which would approximate field drilling conditions to accomplish the tests.
2. Treatment of a native clay fresh water drilling fluid with the water-loss reducing agent, keeping accurate check of the water-loss reduction effected and the quantities of agent used; at the same time maintaining the properties of the fluid within a pre-determined range of viscosity, gel strength, density, and pH with a commonly used field method for chemical control.
3. Determination of the water-loss at a temperature approximating that which the drilling fluid would reach during drilling (172° F.), and a differential pressure representative of well conditions (500 pounds per square inch).
4. Calculation of the cost of the amount of water-loss reducing agent plus the amount of the chemicals required for control per barrel of fluid being circulated.
5. Comparison of the cost to effect a given water-loss for a starch and native clay drilling fluid system, sodium carboxymethylcellulose and native clay system, and an emulsion and native clay system.

TABLE 1

Average properties of McKittrick clay-water fluid before circulating and heating.

Density	9.3 lb./gal.
Viscosity: Marsh Funnel A.P.I.	31.0 sec.
Stormer	8.0 cp.
Initial gel strength	5.0 g.
Ten minute gel strength	50.0 g.
pH	9.4
Water-loss A.P.I.	18.5 cc.
Filter cake thickness	1/32 in.
Water-loss at 500 psi	25.2 cc.
Filter cake thickness	2/32 in.

Description of Apparatus

The apparatus which was used to circulate the drilling fluid being tested is termed a recirculator and was developed by Norman E. Martello, research engineer for Calgon, Inc., who described it in a recent article.

The procedure followed in making all of the runs was kept as nearly uniform as possible. A weighed quantity of fluid was placed in the recirculator and brought up to a temperature of 172° F. while being circulated continuously. After circulating for one hour at a constant temperature of 172° F., a sample of the fluid was withdrawn and the Stormer viscosity in centipoises, density in pounds per gallon, pH, gel strength in grams, and water-loss at 172° F. and 500 pounds psi were determined. The first addition of water-loss reducing agent was then begun, and the fluid was circulated for one hour, after which the properties of the fluid were again determined.

The viscosity of the fluid was kept below an upper limit of 35 centipoises by water dilution and sodium hydroxide-quebracho treatment; the density maintained as closely as possible to 9.3 pounds per gallon by the addition of

a commercial drilling fluid weighting agent of barium sulfate; the gel strength ratio, or thixotropic ratio (ratio of final or ten minute gel strength to initial gel strength) maintained as close to ten as possible; and the pH maintained between 9.3 and 12.0.

Considerable time was consumed in adjusting the gel strength, viscosity, pH and density to maintain them within the desired ranges during the runs, but this was considered necessary in order to evaluate the water-loss reducing agents on a comparable basis and because such conditions must generally be followed in field practice.

Addition of the water-loss reducing agent was discontinued when the concentration reached approximately ten pounds per barrel (2.5 percent by weight in the runs with the sodium carboxymethylcellulose and starch, and 25 percent by volume of the oil base stock in the emulsion runs.

The system was then contaminated with calcium (5 percent by weight of powdered anhydrite), the effect noted, and treatment made to restore the fluid to the desired range of properties without further addition of water-loss reducing agent.

A similar procedure was followed using 5 percent by weight of sodium chloride.

Once the run was begun it was carried through to completion without interruption of circulation, and a constant temperature within plus or minus 1° F. was maintained.

A materials balance was recorded so that the contents of the system were known at all times throughout the runs.

Selection of Clay

Consideration was given to several factors in the selection of a suitable clay to be used throughout the tests. In order to approximate field conditions as closely as possible, it was believed that a native clay, commonly used in the field, having a fairly high yield (25 to 35 barrels per ton), and requiring a minimum of pre-treatment to secure a fluid of the desired viscosity, gel strength, density, pH and water-loss properties should be used. A clay conforming to the above requirements, known as "McKittrick Light," was employed to make up the base fluid.

Preparation of Fluid

The clay was mixed in a 20-gallon container with sufficient water to insure complete hydration and stirred from eight to ten hours per day for a period of one week by means of a specially designed paddle attached to a high speed electric stirrer to insure a maximum of agitation.

After hydration for one week, the resulting fluid was screened by hand through a standard Tyler screen (100 mesh) to remove sand and non-hydratable material. The fluid was then thinned with water to 45 seconds API viscosity, and stirred continuously for three days.

Prior to each run, the fluid was stirred for four hours and thinned with water to approximately 31 seconds API viscosity. Average properties of the fluid before any heating or treatment are shown in Table 1. These properties were considered satisfactorily representative of a field drilling fluid, and consequently, no pretreatment was required before commencing a run.

Prior to making the runs in the recirculator, extensive pilot tests were conducted to determine the most satisfactory range of viscosity and gel strengths of the fluid, in order that these properties might be controlled and yet insure as wide a range of values as possible. For these pilot tests, 700 cubic centimeter samples of fluid and several types of viscosity treating agents were used. Heating of the samples was done in a simple water bath. No attempt was made to obtain close checks or accurate results, but rather to determine in advance the chemical agents to be used for treating and an approximate idea of the behavior of the fluid when additions and treatment were made.

The sodium hydroxide-quebracho viscosity control treatment was selected since it was the only type of common field treatment which would work successfully on all three fluid systems.

Effect of Temperature and Pressure on Water-Loss Determinations

Properties of the McKittrick Light clay-water fluid at different temperatures, using differential pressures of 100 and 500 psi as shown in Table 4, run number 6, tests "a" through "f." Since the high-pressure tester used in water-loss determinations has a diameter of 2.125 inches as compared to the API tester of 3.065 inches, the water-loss figures tabulated as "converted water loss" were obtained by multiplying the experimental results by a factor of 2.074 to secure the same results as would have been obtained with the API tester.

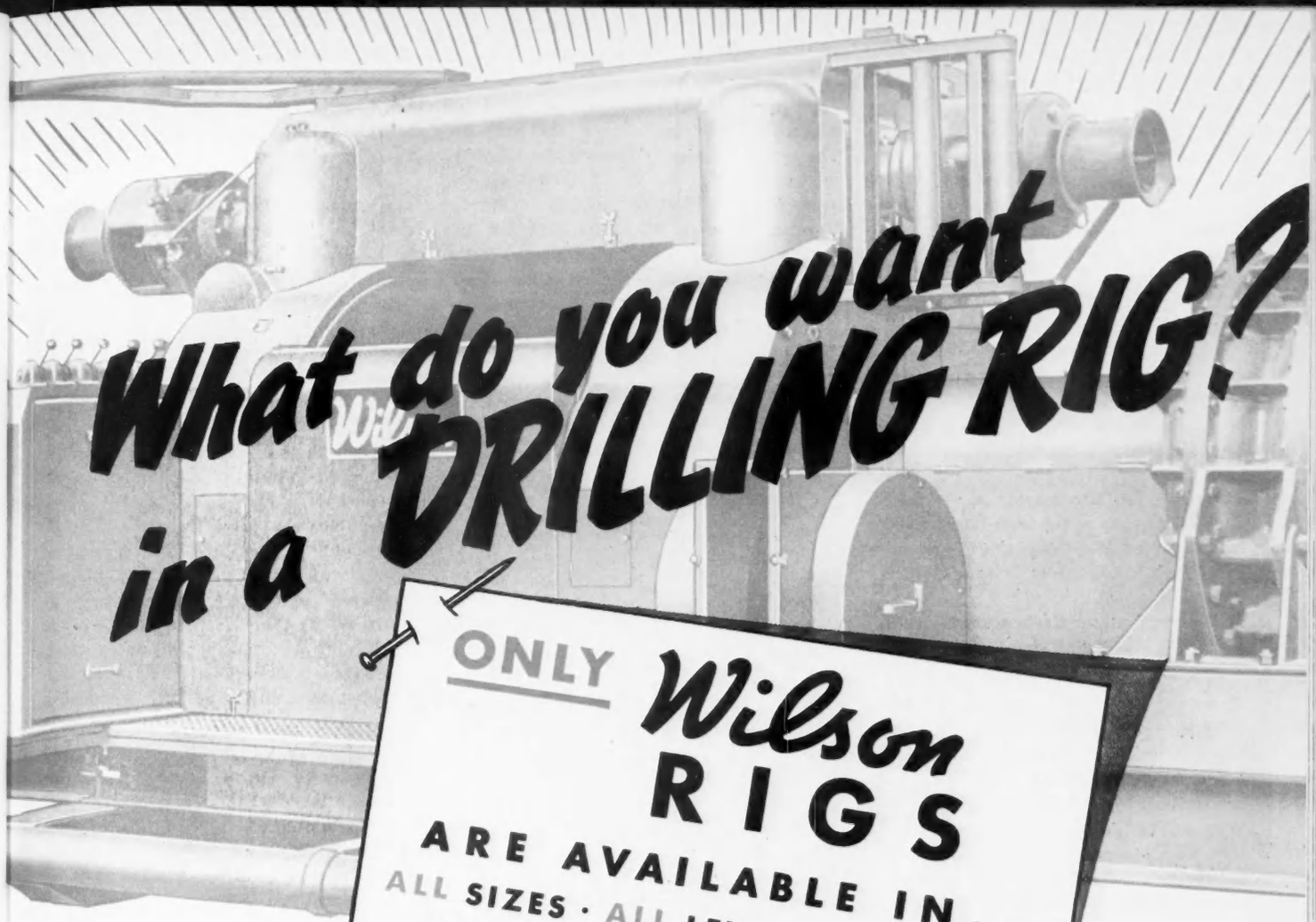
The converted water loss is plotted against temperature for pressures of 100 and 500 psi in Figure 1. It can be seen that the relationship between water loss and temperature is a straight line on a semi-logarithmic plot. This is in agreement with the results of other investigators.

It is routine field practice to determine the water loss of fluids without considering or reporting the temperature of the test, although the API code recommends 100°. In comparing the water-loss characteristics of two or more fluids, it can be seen from Figure 1 that results should be used which were obtained at the same temperature in

TABLE 2

Properties of McKittrick clay-water fluid with additions of sodium of carboxymethylcellulose.

Run Number	Test Number	Sodium Carboxy. in Fluid Percent by Weight	WATER-LOSS				FILTER CAKE THICKNESS		Density Lb./Gal.	VISCOSITY			GEL STRENGTH		pH	Temp. deg. F.
			100 psi. cc.	Converted 100 psi. cc.	500 psi. cc.	Converted 500 psi. cc.	100 psi. In.	500 psi. In.		Marsh Funnel API Secs.	Stormer cp.	Brookfield Units	Initial g.	10 Minute g.		
1	a	.000	8.0	16.59	11.4	23.64	1/64	1/32	9.2	31	10.0	0	5	45	9.6	84
	b	.000			21.0	43.55		3/64	9.2		2.0	0	2	37.5	9.6	172
	c	.100			13.2	27.38		2/32	9.2		13.5	20	7.5	107.5	9.6	171
	d	.300			11.5	23.85		2/32	9.2		42.5	35	37.5	220	9.5	172
	e	.279			15.8	32.77		2/32	9.1		26.7	28	32.5	230	10.2	172
	f	.500			10.7	22.19		3/32	9.1		26.0	28	37	185	10.5	172
	g	.700			9.4	19.50		3/32	9.0		26.0	28	17	177	11.0	172
	h	1.000			8.5	17.63		2/32	9.2		25.5	30	10	60	10.8	172
	i	1.500			7.4	15.35		3/64	9.2		42.5	40	8	87	11.1	172
	j	2.000			7.2	14.93		1/32	9.2		68.0	120	27	107	11.3	172
2	a	.000	8.5	17.63	12.0	24.89	1/32	1/32	9.2	31	9.0	0	4	42	9.3	84
	b	.000			22.0	45.63		2/32	9.0		2.0	0	2	37	9.3	172
	c	.100			17.8	36.92		2/32	9.0		10.0	0	2	77	9.3	172
	d	.300			13.5	28.00		2/32	9.0		20.5	80	12	157	9.3	172
	e	.377			13.1	27.17		2/32	8.9		24.5	50	27	190	9.2	172
	f	.474			11.2	23.23		2/32	9.2		21.5	40	7	107	10.5	172
	g	.670			10.6	21.98		2/32	9.2		21.5	25	5	70	10.4	172
	h	.884			9.3	19.29		5/64	9.2		38.0	25	7	105	11.2	172
	i	1.020			8.8	18.25		5/64	9.2		40.0	35	8	120	11.3	172
	j	1.500			7.3	15.14		5/64	9.1		35.0	40	8	110	11.3	172
	k	2 000			7.1	14.73		5/64	9.1		33.0	35	6	105	11.4	172
	l	2.500			7.0	14.52		5/64	9.3		30.0	40	7	110	....	172



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order for the comparison to be of any value. (See Figure 1.)

The accepted field practice is to report water-loss determinations at 100 psi, a differential pressure which is considerably lower than that encountered in the well during drilling. From Figure 1 it can be seen that a differential pressure of 500 psi, which is representative of well conditions, gives a much greater water loss.

Thus, in order to get a true picture of the water-loss property of a fluid, both for comparative purposes for different drilling fluids and for consideration of the detrimental effect of the water lost to the formation, it is important that the water-loss determination be conducted at a temperature and pressure approximating well conditions.

Effect of Sodium Carboxymethylcellulose on Water Loss

Properties of the McKittrick Light clay-water fluid during the sodium carboxymethylcellulose runs are shown in Table 2. Water-loss determinations were made at the beginning of the runs at a temperature of 84° F., using differential pressures of 100 and 500 psi. After each addition of sodium carboxymethylcellulose and period of circulation, a water-loss determination at 500 psi and 172° F. was made. Viscosity, density and pH were kept within the limits established, treatment being made when necessary.

Sodium carboxymethylcellulose produced an immediate increase in viscosity of the fluid which was controlled by the addition of water and with sodium hydroxide - quebracho treatment. Water dilution reduced the density somewhat and additions of barium sulfate were made when necessary to keep the density within the desired range. (See Table 2.)

Converted water loss at 500 psi and 172° F. is plotted against percent by weight of sodium carboxymethylcellulose in the fluid for run number 2 in Figure 2. For convenience, the scale at the top of Figure 2, showing the amount of sodium carboxymethylcellulose in pounds per barrel of fluid, is included. It can be seen that the addition of sodium carboxymethylcellulose produces an appreciable decrease in water loss until a concentration of 1 percent by weight, or approximately four pounds per barrel of fluid, is reached. The decrease in water loss then levels off, and no appreciable reduction is obtained by increasing the concentration of the sodium carboxymethylcellulose.

Effect of Starch on Water Loss

Properties of the fluid during the starch runs are shown in Table 3. Water-loss determinations were made at the beginning of the runs at 500 psi and an average temperature of 84° F. After each addition of starch and period of circulation, a water-loss determination at 500 psi and 172° F. was made.

Prior to the addition of any starch, the pH was raised to approximately 12.0 in order to obtain the maximum yield from the starch and to simulate the conditions of high alkalinity which would be followed using a high pH to prevent fermentation of the starch. Increase in viscosity of the fluid with the addition of starch was considerably less than the increase occurring with sodium carboxymethylcellulose, and less dilution and sodium hydroxide-quebracho treatment was required to control the viscosity in the range desired. Less barium sulfate was required to maintain the density at the desired figure. (See Table 3.)

Converted water loss at 500 psi and 172° F. is plotted against the percent by weight of starch in the fluid for run number 4 in Figure 2. The scale at the top of the figure shows the concentration of starch in pounds per barrel of fluid.

It can be seen that this curve is very similar to the sodium carboxymethylcellulose results. Considerable decrease in water loss is effected up to a concentration of 1 percent by weight, or approximately four pounds per barrel of fluid. Increasing the starch concentration above this produces only a small decrease in water loss.

Properties of the fluid during the emulsion runs are shown in Table 4. For run number 5, water-loss determination was made at 85° F. and 500 psi at the beginning of the run, and at 172° F. at the same pressure before any addition of oil-base stock was made. After each addition of oil-base stock and period of circulation, a water-loss determination at 500 psi and 172° F. was made. For run number 6, water-loss determinations at both 100 and 500 psi were made at temperatures as shown in the table. After a temperature of 172° F. was reached, oil-base stock was added, the fluid circulated for one hour between additions, and water-loss determinations made at 500 psi and 172° F.

In order to secure thorough emulsification of the oil-base stock, it is necessary to withdraw 500 cc. samples of fluid from the recirculator and emulsify small amounts of oil-base stock in these samples using a high-speed mixer. Decrease in viscosity, reduction in density, and increase in volume occurred with each addition of oil-base stock. Above 10 percent by volume of oil-base stock, the resulting emulsion foamed considerably. Viscosity and gel strength of the emulsion fluid were lower than the desired values in run number 5. The addition of some bentonite and closer control of pH with sodium hydroxide in run number 6 kept the viscosity and gel strength within the desired ranges. (See Table 4.)

Converted water loss at 500 psi and 172° F. is plotted against percent by volume of oil-base stock in the fluid for run number 6 in Figure 2. The scale at the top of the figure shows the

TABLE 3

Properties of McKittrick clay-water fluid with additions of starch.

Run Number	Test Number	Starch in Fluid Percent by Weight	WATER-LOSS				FILTER CAKE THICKNESS		Density Lb./Gal.	VISCOSITY			GEL STRENGTH		pH	Temp. deg. F.
			100 psi. cc.	Converted 100 psi. cc.	500 psi. cc.	Converted 500 psi. cc.	100 psi. In.	500 psi. In.		Marsh Funnel API Secs.	Stormer cp.	Brookfield Units	Initial g.	10 Minute g.		
3	a	.000			10.4	21.57		1/32	9.2	30.5	8.0	0	3	45	9.4	86
	b	.000			19.0	39.41		2/32	9.1		5.0	0	2	62	9.6	172
	c	.100			18.4	38.16		2/32	9.4		6.0	0	2	77	11.6	172
	d	.298			14.7	30.49		5/64	9.2		10.0	10	3	95	11.9	172
	e	.472			13.5	28.00		5/64	9.4		18.0	25	5	95	11.9	171
	f	.621			11.0	22.81		5/64	9.2		16.0	20	7	125	11.8	172
	g	.883			9.0	18.67		2/32	9.2		26.0	40	10	150	11.8	172
	h	1.170			7.2	14.93		2/32	9.1		21.0	30	12	120	12.2	172
	i	1.411			5.3	10.99		5/64	9.4		20.5	30	5	55	12.0	172
4	a	.000			12.0	24.39		1/32	9.3	31	8.0	0	3	37	9.3	82
	b	.000			21.0	43.55		2/32	9.2		5.0	0	3	57	9.5	172
	c	.200			18.0	37.33		5/64	9.2		6.0	0	10	90	11.9	172
	d	.448			13.0	26.96		5/64	9.3		10.0	10-15	5	77	11.9	173
	e	.693			10.4	21.57		5/64	9.3		13.5	15	10	77	11.9	172
	j	.986			8.6	17.84		5/64	9.2		15.0	20	7	87	11.5	172
	g	1.280			7.6	15.76		5/64	9.2		24.5	45	12	127	11.1	171
	h	1.657			6.3	13.07		5/64	....		28.0	50	12	87	12.1	172
	i	2.452			5.7	11.82		5/64	9.2		33.0	30	15	105	12.0	172

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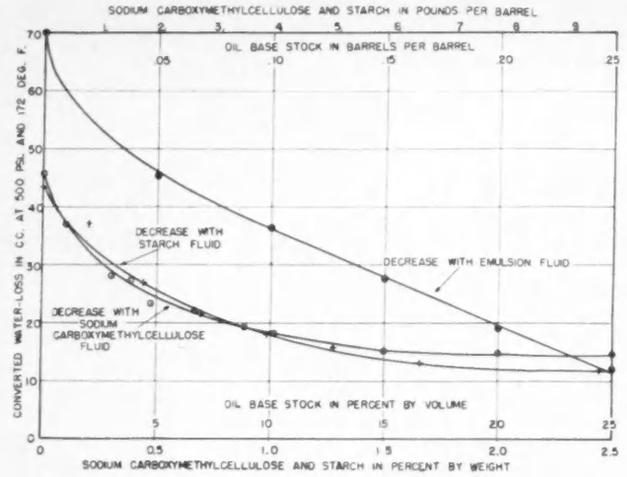
SODIUM CARBOXYMETHYLCELLULOSE AND STARCH IN POUNDS PER BARREL
OIL BASE STOCK IN BARRELS PER BARREL
CONVERTED WATER-LOSS IN CC. AT 500 PSI AND 172 DEG. F.
DECREASE WITH STARCH FLUID
DECREASE WITH EMULSION FLUID
DECREASE WITH SODIUM CARBOXYMETHYLCELLULOSE FLUID
OIL BASE STOCK IN PERCENT BY VOLUME
SODIUM CARBOXYMETHYLCELLULOSE AND STARCH IN PERCENT BY WEIGHT

FIGURE 2. Decrease in water-loss obtained with water-loss reducing agents.

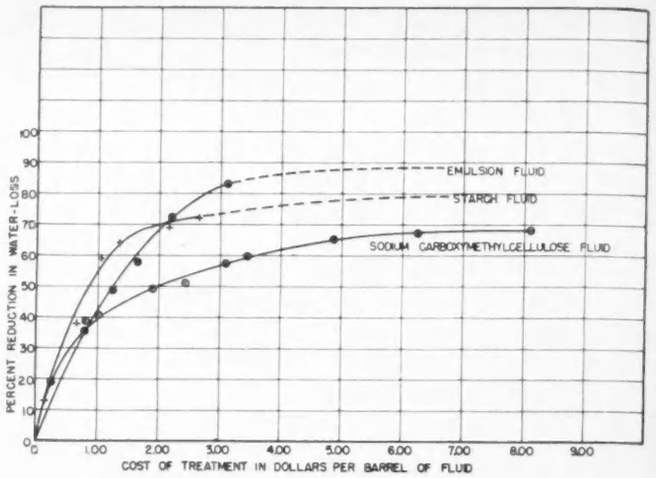
EMULSION FLUID
STARCH FLUID
SODIUM CARBOXYMETHYLCELLULOSE FLUID
PERCENT REDUCTION IN WATER-LOSS
COST OF TREATMENT IN DOLLARS PER BARREL OF FLUID

FIGURE 3. Cost of treatment for water-loss reduction.

concentration of oil-base stock in barrels per barrel of fluid. It can be seen that the water loss of the fluid prior to the addition of any oil-base stock is considerably higher than the water loss for runs 2 and 4. No explanation for this is offered, although it may possibly be due to the longer period of circulation in run number 6. A rapid reduction in water loss occurs with the addition of 5 percent by volume of oil-base stock and reduction continues to occur until 25 percent by volume is reached. In run number 5, the concentration of oil-base stock was increased to 30 percent by volume but produced very little decrease in water-loss from the 25 percent figure. In addition, in run number 5, the last 5 percent of oil-base stock did not completely emulsify in the fluid.

Cost of Treatment

In tables 5, 6, and 7 are shown the calculations made to determine the cost of treatment to obtain a decrease in water loss.

These calculations are based on the following unit costs of materials:

Sodium carboxymethyl-cellulose	$0.70	per lb.
Sodium hydroxide	0.035	per lb.
Quebracho	0.09	per lb.
Barium sulfate	0.016	per lb.
Starch	0.15	per lb.
Bentonite	0.0215	per lb.
Barium carbonate	0.08	per lb.
Oil-base stock	8.00	per bbl.

Values in Table 5 were based on results from run number 2, in Table 6 from run number 4, and in Table 7 from run number 6.

The method of calculation of costs was essentially the same for all three tables. Knowing the total weight of fluid in the recirculator for the run and the density of the fluid, the volume of fluid was calculated in barrels. From the materials balance recorded, the weight in pounds for each addition of material was recorded. From these figures the concentration in pounds per barrel for each material was then calculated. Knowing the volume of the system in barrels, the concentration of each material in pounds per barrel, and the cost of the material per pound, the cost of treatment was calculated for each water-loss reduction.

As indicated in the headings of the tables, the figures for amounts of materials and costs are cumulative. Progressing from left to right is shown the amount and cost of the water-loss reducing agent, the amount and cost of the chemicals necessary to maintain the properties in the desired ranges, the total cost of treatment, and the cost of treatment per barrel of fluid for the water loss obtained.

The first entry in the tables shows the water loss of the fluid before addition of any materials was made. Since the water loss of the fluid was not the same during the three runs before the addition of any materials, in order to properly compare the cost of treatment for the reduction in water loss, the percent decrease in water loss is shown.

Comparsion of the cost of treatment for the three water-loss reducing agents can be seen in Figure 3. The percent decrease in water loss is plotted against the cost of treatment in dollars per barrel of fluid for the three agents.

Referring to Figure 3, the following information can be secured:

1. To obtain a 25 percent reduction in water loss of the fluid, the most economical agent to use would be starch, followed by sodium carboxymethylcellulose and emulsion.

2. To obtain a 50 percent reduction in water loss of the fluid, starch would be the most economical, followed by emulsion and sodium carboxymethylcellulose.

3. To obtain a 75 percent reduction in water loss of the fluid, emulsion would be the most economical followed by starch and sodium carboxymethylcellulose.

4. In relative magnitude of costs, above 40 percent reduction in water loss, sodium carboxymethylcellulose is considerably higher than starch or emulsion treatment.

5. Maximum percent reduction in water loss can be obtained using emulsion treatment when cost of treatment increases beyond $2.25 per barrel of fluid.

In comparing the three fluids, it must be recognized that several other factors enter into the over-all cost of using a particular type of water-loss reducing agent. One important factor which is not included in the tables nor represented in the figures, is the effect of calcium or salt contamination on the fluids and the additional cost of treatment involved.

It should be pointed out that in the use of sodium carboxymethylcellulose, no additional cost of treatment is incurred for either calcium or salt contamination, and no appreciable change in water loss occurs.

With the starch fluid, treatment for calcium contamination increased the cost from $2.621 per barrel to $4.465 per barrel; with the emulsion fluid, treatment increased the cost from $3.321 to $5.040 per barrel. A commercial calcium treating agent of barium carbonate was used to remove the calcium contamination. The water-loss of both of the fluids, starch and emulsion, returned to approximately the same values when the calcium contamination was removed.

Salt contamination caused an increase in cost from $2.621 to $3.641 per barrel of the starch fluid to restore the water-loss to its approximate value before contamination. With the emulsion fluid, the cost increased from $3.231 to $6.100 per barrel.

From the above, it can be seen that

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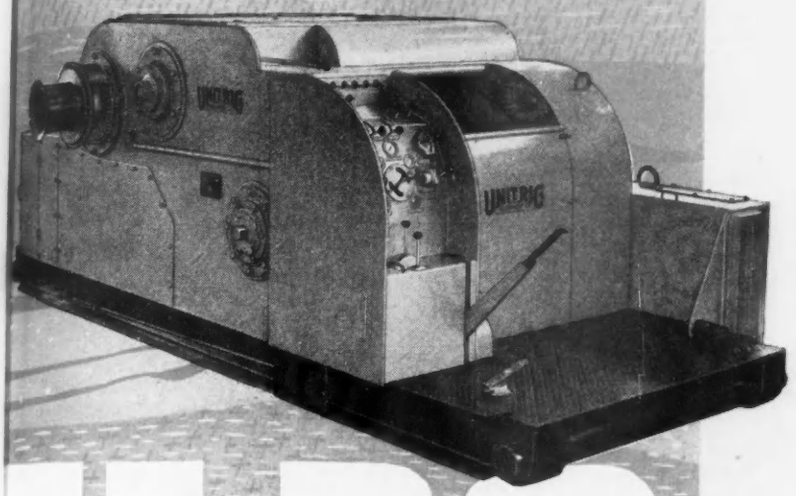

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prolonged contamination by either salt or calcium would soon increase the cost of the starch and emulsion fluids beyond that of the sodium carboxymethylcellulose.

Summary and Conclusions

From the results obtained in this investigation the following conclusions were reached:

1. An apparatus such as the recirculator used in the investigation provides a satisfactory method of simulating conditions that a drilling fluid would encounter in a well.

2. Water loss increases with temperature for a fluid composed of McKittrick Light clay and water, the relationship being a straight line when plotted on semi-logarithmic paper.

3. An appreciable increase in water loss occurs with increased differential pressure, as shown by the results obtained using McKittrick Light clay-water fluid at 100 and 500 psi.

4. In order to accurately compare water-loss characteristics for different fluids and in order to obtain a more representative idea of the actual water lost to the formation from the drilling fluid, water-loss determinations on different fluids should be conducted at the same temperatures and pressures; these temperatures and pressures should approximate well conditions.

5. A comparison of the water-loss characteristics of McKittrick Light clay-water fluid when treated with sodium carboxymethylcellulose, or starch, or oil-base stock shows the following:

(a) Starch and sodium carboxymethylcellulose fluids yield very similar reductions in water loss.

(b) Upon initial treatment, emulsion fluid gives a sharper reduction in water loss than starch or sodium carboxymethylcellulose.

(c) With starch and sodium carboxymethylcellulose, reduction in water loss occurs until a concentration of 1 percent by weight or approximately four pounds per barrel of fluid is reached, after which reduction is slight.

(d) Appreciable reduction in water loss occurs with emulsion fluid until a concentration of 25 percent by volume of oil base stock is used, after which a negligible reduction occurs.

(e) The water-loss value for all three agents is approximately the same when the concentration of starch or sodium carboxymethylcellulose is 2.5 percent by weight and the concentration of emulsion is 25 percent by volume.

6. The behavior of McKittrick Light clay-water fluid when treated with the three water-loss reducing agents is as follows:

(a) Addition of sodium carboxymethylcellulose in small amounts causes a rapid rise in viscosity which must be controlled by water dilution and chemical treatment.

(b) Reduction in density, caused by water dilution to decrease viscosity, must be overcome by addition of a weighting agent, when sodium carboxymethylcellulose is added for water-loss treatment.

(c) Control of viscosity, density, pH and gel strength is easier with a starch fluid than a sodium carboxymethylcellulose fluid; rise in viscosity and gel strength is less, and properties can be maintained easier.

(d) In making an emulsion fluid, complete emulsification of the oil-base stock in the clay-water fluid required extreme turbulence.

(e) Pronounced reduction in viscosity and gel strength occur when oil-base stock is added to produce an emulsion fluid; addition of some bentonite and increase in pH by addition of sodium hydrox-

TABLE 4

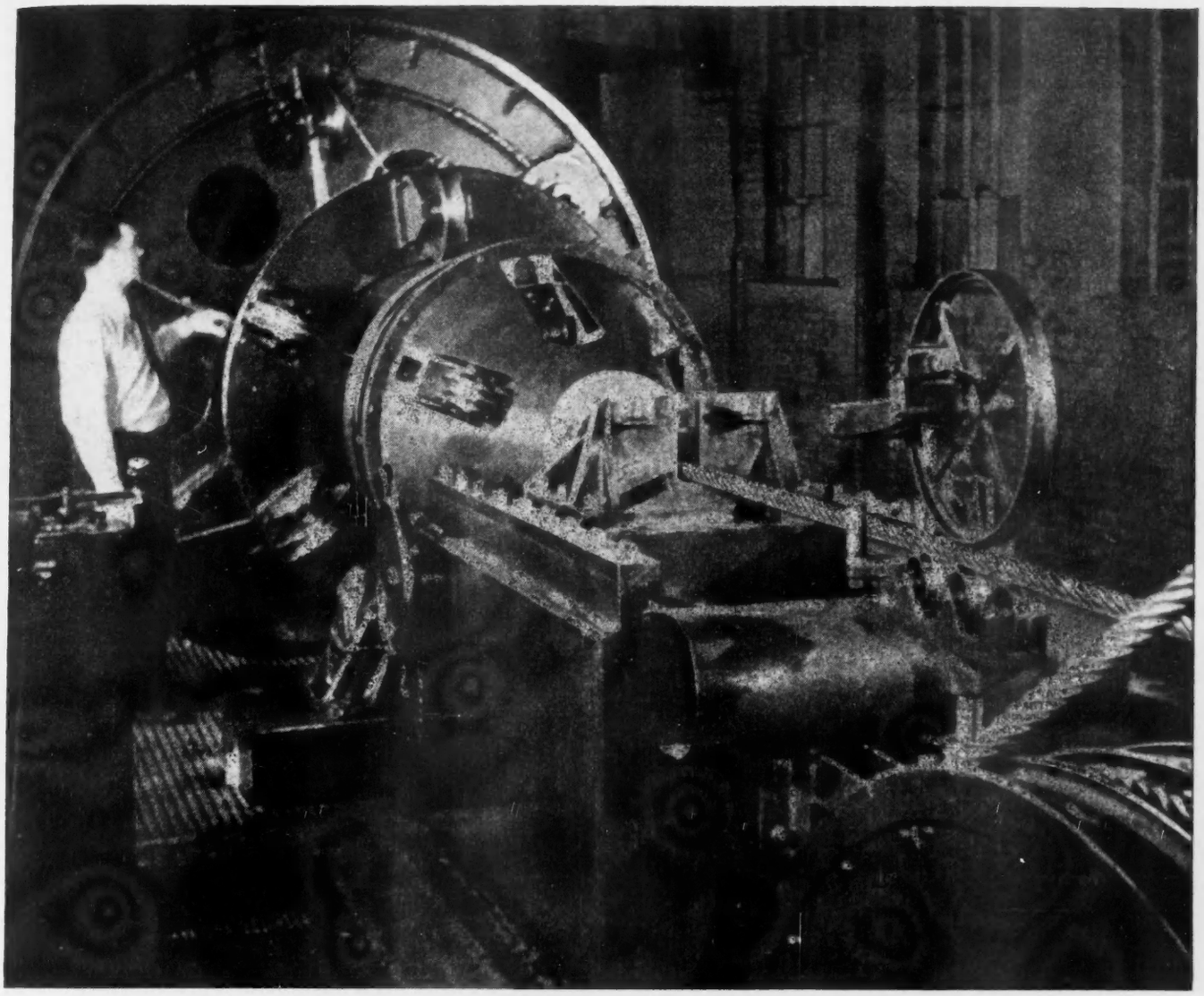
Properties of McKittrick clay-water emulsion fluid.

Run Number	Test Number	Oil Base Stock in Fluid Percent by Volume	WATER-LOSS				FILTER CAKE THICKNESS		Density Lb./Gal.	VISCOSITY			GEL STRENGTH		pH	Temp. deg. F.
			100 psi. cc.	Converted 100 psi. cc.	500 psi. cc.	Converted 500 psi. cc.	100 psi. In.	500 psi. In.		Marsh Funnel API Secs.	Stormer cp.	Brookfield Units	Initial g.	10 Minute g.		
5	a	.000			11.5	23.85		2/32	9.2	31.5	7	0	7	40	9.3	85
	b	.000			21.5	44.59		2/32	9.2		3	0	3	55	9.3	172
	c	5.000			12.1	25.10		2/32	9.1		2	0	2	30	9.3	172
	d	10.000			10.0	20.74		2/32	9.0		2	0	1	3	9.3	172
	e	15.000			7.9	16.38		2/32	8.9		1	0	0	0	9.2	172
	f	20.000			6.9	14.31		2/32	9.2		5	0	2	20	10.5	172
	g	25.000			5.5	11.41		2/32	9.3		20	25	10	70	11.0	172
	h	30.000			5.2	10.78		2/32	9.2		3	0	5	55	10.9	172
6	a	.000	14.0	29.04	18.4	38.16	1/32	1/32	9.1	31.5	3.5	0	10	35	9.3	86
	b	.000	16.0	33.18	20.2	41.90	1/32	1/32								104
	c	.000	18.4	38.16	22.9	47.50	3/64	3/64								122
	d	.000	20.5	42.52	25.9	53.72	3/64	3/64								140
	e	.000	23.6	48.95	29.3	60.77	2/32	2/32								158
	f	.000	27.2	56.41	33.9	70.31	2/32	2/32			3.0	0	2	50	9.3	172
	g	5.000			21.8	45.21		5/64	9.3		3.5	0	2	32	10.0	172
	h	10.000			17.5	36.30		2/32	9.3		10.0	10	4	60	10.5	172
	i	15.000			14.3	27.66		2/32	8.9		8.0	0	2	47	10.8	172
	j	20.000			9.3	19.29		2/32	9.1		12.0	10	6	70	11.5	172
	k	25.000			5.8	12.03		....	9.0		16.5	20	7	85	11.0	172

TABLE 5

Cost of treatment using sodium carboxymethylcellulose to obtain decrease in water-loss.

SODIUM CARBOXYMETHYLCELLULOSE				BARIUM SULFATE		SODIUM HYDROXIDE		QUEBRACHO		Total Cost for Treatng Dollars	Cost Per Bbl. of Fluid Dollars	Water-Loss Converted 500 psi cc.	Decrease in Water-Loss Percent
Cumulative Percent by Weight	Cumulative Weight Pounds	Cumulative Lb./Bbl. in Fluid	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars				
.000	.000	.000	.000							.000	.000	45.63	.000
.100	.0203	.3878	.0142							.0142	.2740	36.94	19.08
.300	.0610	1.162	.0426							.0426	.8221	28.00	38.63
.377	.0766	1.461	.0536							.0536	1.0345	27.17	40.46
.474	.0961	1.832	.0673	1.764	.0282	.0406	.00142	.0232	.001827	.09875	1.9059	23.23	49.09
.670	.1361	2.595	.0953							.12675	2.4462	21.98	51.83
.884	.1795	3.421	.1256			.0610	.002139	.03022	.00274	.158679	3.0624		
						.0928	.003250	.05075	.00456	.16161	3.1190	19.29	57.53
1.020	.2075	3.960	.1450							.18101	3.4934	18.25	60.00
1.500	.3045	5.815	.2135							.24951	4.8155		
						.1218	.004260	.0813	.00731	.25327	4.8881	15.14	66.82
2.000	.4064	7.740	.2843							.32407	6.2545	14.73	67.72
2.500	.5075	9.680	.3552	3.528	.0564	.1420	.004960	.1025	.00914	.42570	8.2159	14.52	68.18



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ide must be done to secure the desired viscosity and gel strength.

7. Contamination with 5 percent by weight of powdered anhydrite or salt has no appreciable effect on water loss, viscosity or gel strength of a McKittrick Light clay-water fluid to which sodium carboxymethylcellulose has been added.

8. Considerable chemical treatment of McKittrick Light clay-water fluid is required to restore or maintain desired water loss, viscosity and gel strength properties when contamination by powdered anhydrite or salt occurs if starch or emulsion is being used to reduce water-loss.

9. A comparison of the cost of treatment of McKittrick Light clay-water fluid using sodium carboxymethylcellulose, starch or oil-base stock to effect reduction in water loss shows the following:

(a) To obtain a 25 percent reduction in water loss the most economical agent to use is starch, followed by sodium carboxymethylcellulose and emulsion.

(b) To obtain a 50 percent reduction in water loss, the most economical agent to use is starch, followed by emulsion and sodium carboxymethylcellulose.

(c) To obtain a 75 percent reduction in water loss, the most economical agent to use is emulsion, followed by starch and sodium carboxymethylcellulose.

(d) Maximum percent reduction in water loss can be secured using an emulsion fluid.

(e) When prolonged contamination by calcium or salt is present, sodium carboxymethylcellulose is the most economical agent to use.

In comparing the cost of treatment for a native clay-water fluid using starch, sodium carboxymethylcellulose or emulsion to reduce the water-loss characteristics, several interrelated factors must be considered, among which are the following:

1. The desired percent reduction in water loss may govern the selection of the agent, i.e., if maximum percent reduction is necessary, it may be required to use an emulsion fluid; if only 50 percent reduction is necessary, starch would be the most economical agent.

2. The effects of calcium or salt contamination may govern the selection of the agent; if prolonged contamination is to be expected, sodium carboxymethylcellulose should be selected; if only slight contamination is expected, either starch or emulsion may be used with proper chemical treatment.

3. The possibility of the relative effectiveness of different types of viscosity treating agents must be considered; for example, phosphate treatment is relatively ineffective on sodium carboxymethylcellulose, but can be used successfully on starch fluids.

4. In the case of starch fluids contaminated by salt, the possibility of converting the system to a saturated salt fluid must be considered.

5. Using starch fluids, the relative cost of the method used to prevent fermentation of the starch must be considered.

6. In the case of emulsion fluids, the additional cost of installing oil resistant rubber equipment and the increased lubrication effects of the fluid resulting in less wear on bits, drill pipe, etc., should be considered.

7. The possibility of reducing the water loss somewhat with the addition of pure bentonite prior to using another agent must be considered.

8. Other chemicals for treatment for calcium contamination might be used which would be cheaper.

9. The native clay used in the base fluid may exercise a dominant influence in selection of the water-loss reducing agent.

It is realized that the multitude of factors entering into the comparison of cost of treatment for water-loss reduction cannot be inflexibly established to follow set rules. However, it is believed that results obtained from an investigation such as the one discussed herewith can be used to advantage in application to field problems.

ACKNOWLEDGMENT

The writer wishes to express his thanks and appreciation to Norman E. Martello, research engineer, Calgon, Inc., for his advice and assistance in the conduct of this investigation, and to the firm of Calgon, Inc., for the use of their laboratories, equipment and facilities. The author is indebted to Professor H. G. Botset, Department of Petroleum Engineering, University of Pittsburgh, for suggestions, criticism and review of this paper.

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TABLE 6
Cost of treatment using starch to obtain decrease in water-loss.

STARCH				BARIUM SULFATE		SODIUM HYDROXIDE		QUEBRACHO		Total Cost for Treating Dollars	Cost Per Bbl. of Fluid Dollars	Water-Loss Converted 500 psi cc.	Decrease in Water-Loss Percent
Cumulative Percent by Weight	Cumulative Weight Pounds	Cumulative Lb./Bbl. in Fluid	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars				
.000	.000	.000	.000							.000	.000	43.55	.000
.200	.04175	.782	.006216			.0535	.001875			.00891	.1515	37.33	13.08
.448	.09360	1.752	.01405	1.110	.01768			.0268	.002406	.036011	.6743	26.96	38.09
.693	.1450	2.715	.02175			.0645	.002261	.0378	.003400	.045091	.8443	21.57	50.47
.986	.2060	3.820	.03090					.0913	.007900	.58741	1.0999	17.84	59.04
1.280	.2678	4.965	.04015							.067991	1.2731	15.76	63.81
1.651	.3445	6.380	.05170	3.330	.05304	.1070	.003750			.116390	2.1793	13.07	69.99
2.452	.5120	9.481	.07680							.141490	2.6439	11.82	72.86

TABLE 7
Cost of treatment using emulsion to obtain decrease in water-loss.

OIL BASE STOCK				BARIUM SULFATE		SODIUM HYDROXIDE		QUEBRACHO		BENTONITE		Total Cost for Treating Dollars	Cost Per BBl. of Fluid Dollars	Water-Loss Converted 500 psi. cc.	Decrease in Water-Loss Percent
Cumulative Percent by Volume	Cumulative Volume Bbls.	Cumulative Lb./Bbl. in Fluid	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars	Cumulative Weight Pounds	Cumulative Cost Dollars				
.000	.000	.000	.000									.000	.000	70.31	.000
5.000	.002405	.0499	.01926	1.103	.01765	.03305	.001158					.38068	.7911	45.21	35.70
10.000	.004810	.0998	.03852			.06610	.002316	.02205	.001985			.060471	1.2566	36.30	48.37
15.000	.007215	.1487	.05778									.079731	1.6569	29.66	57.82
20.000	.009620	.1996	.07704			.10925	.003822	.04410	.003970	.1800	.003803	106285	2.2087	19.29	72.56
25.000	.012025	.2495	.09630	2.206	.03530	.16445	.005760	.07548	.00678	.5400	.011409	.155555	3.2324	12.03	82.89

Flow Properties OF DRILLING MUD

By T. H. DUNN, Research Group Supervisor,
W. F. NUSS, Research Engineer, and
R. W. BECK, Chemist,
Stanolind Oil & Gas Company

IT IS generally known in the petroleum industry that drilling muds have a more complex flow behavior than true fluids, yet it is still common practice to express the flow properties of muds in terms of a single viscosity value.

The flow properties of true fluids are accurately defined in the regions of viscous and turbulent flow by Poiseuille's law and the Fanning equation, respectively. These two equations require a knowledge only of the viscosity and density, which are easily determinable characteristics of a true fluid. It is unfortunate that most drilling muds are not true fluids, but are instead, plastic materials which obey the laws of plastic flow.

Although the difference between plastic flow and the flow of true fluids was recognized at an early date, a satisfactory quantitative expression for plastic flow was not developed until about 1920, when E. C. Bingham[1] published his book, "Fluidity and Plasticity." Bingham's equation was found to be applicable and useful to industries dealing with ceramics, paints, sewage disposal, and soil physics. Evans and Reid[2] of the Burmah Oil Company, Ltd., comprehended the importance of mud flow properties in the applications of the Bingham equation to certain drilling mud problems. Also Gregory,[3] Ambrose,[4] Loomis,[4] Pigott,[5,6] and a number of other investigators recognized the anomalous character of drilling mud but infortunately, little advantage has been taken of such available information in solving drilling problems. Wilhelm and Wroughton,[7] and Loeffel[8] in 1939 studied the variation of cement slurry viscosity with rate of shear, and Caldwell and Babbitt[9] in 1941 published a paper relating to the flow of sludges and other suspensions in pipe, giving equations which were verified experimentally.

Notwithstanding the significant amount of past work conducted on plastic flow, there appeared to be an unfortunate gap between theory and its general application to drilling problems involving the flow of drilling mud. The investigation described herein was undertaken for the purpose of developing a simple method of determining the flow characteristics of drilling fluids and applying the information to drilling problems.

THE NECESSITY for complete data on flow properties of drilling fluids has been recognized, but lack of a convenient method for determining such properties has hitherto prevented development of mud flow data for routine application to drilling problems. Knowledge of the flow characteristics of drilling fluids is of advantage in nearly all phases of drilling operations. Some of the more important applications relate to loss of mud to drilled formations and selection and design of muds and mud circulating systems to obtain optimum rates of circulation to remove bit cuttings and increase drilling rates.

Theory of Plastic Flow

The differentiation between plastic materials and true fluids was expressed in 1859 by Clerk Maxwell[10] in his "Theory of Heat":

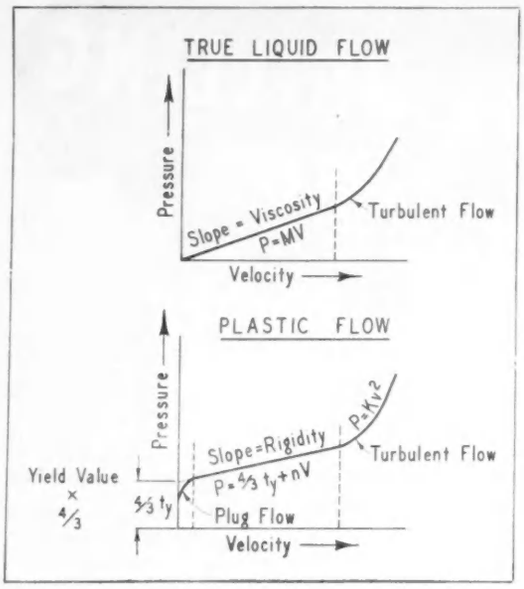
"If the form of the body is found to be permanently altered when the stress exceeds a certain value, the body is said to be plastic, and the state of the body when the alteration is just going to take place is called the limit of perfect elasticity. If the stress, when it is maintained constant, causes a strain or displacement in the body which increases continually with time, the substance is said to be viscous.

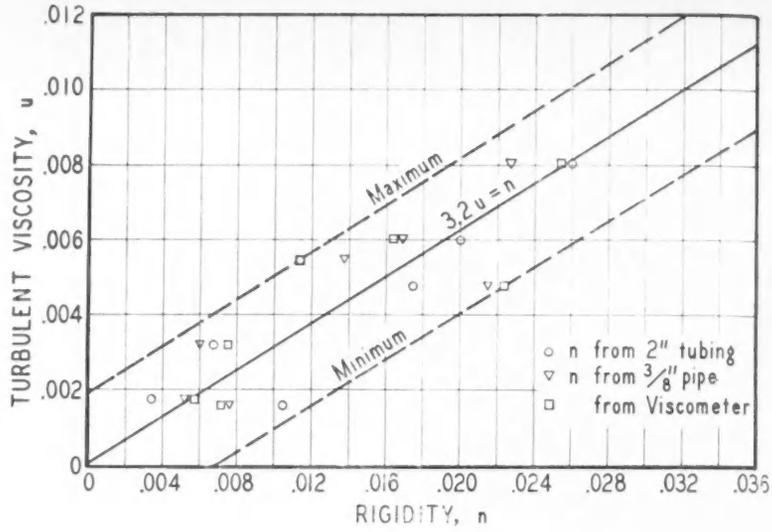
"When this continuous alteration of form is only produced by stress exceeding a certain value, the substance is called a (plastic) solid, however soft it may be. When the very smallest stress, if continued long enough, will cause a constantly increasing change of form, the body must be regarded as a liquid, however hard it may be."

A graphic illustration of the differences between plastic flow and true fluid flow is shown in Figure 1, representing flow in a cylindrical pipe. For a true fluid the pressure differential during streamline flow is proportional to the velocity, resulting in a straight line passing through the origin, the slope of which is a direct function of the viscosity. Under conditions of plastic flow, the pressure differential plus a constant is proportional to the velocity, the constant being a direct function of the initial shearing stress or yield value of the plastic material. The slope of the plastic curve is proportional to the reciprocal of the mobility as Bingham defines it, or to the coefficient of rigidity of the material as defined by Caldwell and Babbitt. The viscosity of the plastic fluid at any given velocity is proportional to the slope of a line from a point on the plastic flow curve corresponding to the given velocity through the origin, thus it can be seen that the viscosity will be an inverse function of the velocity.

In drill pipe or annulus, the shearing force on the material is greatest at the pipe wall and decreases with distance from the wall. At low velocities, the shearing force at some point inside the tube may become insufficient to overcome the yield value of the plastic. The material inside this radius will then flow as a solid plug, causing the downward trend as the plastic flow curve approaches zero velocity.

At higher velocities the flow of plastic material becomes turbulent, as does the flow of a true fluid. The velocity at which this occurs is known as the critical velocity, and above the critical velocity drilling muds behave in the same manner as true liquids in that the pressure differential is a function of a higher power of the velocity.





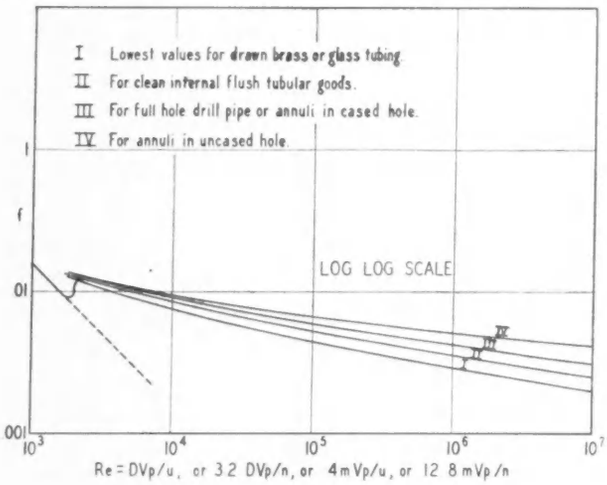

I Lowest values for drawn brass or glass tubing
II For clean internal flush tubular goods.
III For full hole drill pipe or annuli in cased hole.
IV For annuli in uncased hole.
f
.01
.001
LOG LOG SCALE
10³ 10⁴ 10⁵ 10⁶ 10⁷
Re = DVp/u, or 3.2 DVp/n, or 4mVp/u, or 12.8mVp/n

FIGURE 1 (Upper Left). Pressure vs. velocity relationship in true liquid flow and in plastic flow.

FIGURE 2 (Upper Right). Correlation between turbulent viscosity and rigidity as determined in experiment for two-inch ID tubing.

FIGURE 3 (Lower Left). Friction factor vs. Reynolds number chart for calculation of turbulent flow pressure drops.

Laminar Flow of Plastic Materials

Bingham showed that the complete laminar flow curve of plastic materials in pipe could be expressed as follows:

$$\frac{U}{t} = \frac{\pi R^3}{4n}\left(A - \frac{4}{3}a + \frac{1}{3}\frac{a^4}{A^3}\right) \quad (1)$$

$\frac{U}{t}$ = volume rate of flow (cubic feet per second)

R = radius of pipe (feet)

n = rigidity of the mud, pounds per second feet

A = shearing stress at the pipe wall (absolute units)

a = shearing stress necessary to overcome the internal friction or yield value.

In this equation, the shearing forces, A and a, are in absolute units. To convert to more useful gravitational units, let

$$t_p = \frac{A}{g}, \; t_p = \text{shearing stress (lbs./sq. ft.)} \quad (2)$$

$$t_y = \frac{a}{g}, \; t_y = \text{yield value (lbs./sq. ft.)} \quad (3)$$

Then:

$$\frac{U}{t} = \frac{\pi R^3 g}{4n}\left(t_p - \frac{4}{3}t_y + \frac{1}{3}\frac{t_y^4}{t_p^3}\right) \quad (4)$$

The mean flow velocity is:

$$V = \frac{U}{t} \times \frac{1}{R^2\pi}$$

$$V = \frac{Rg}{4n}\left(t_p - \frac{4}{3}t_y + \frac{1}{3}\frac{t_y}{t_p^3}\right) \quad (5)$$

It can be shown that:

$$t_p = \frac{DP}{4L} \quad (6)$$

where P is the pressure gradient in lbs./sq. ft., L is the pipe length, and D the pipe diameter.

Substituting this value of t_p in Equation 5,

$$V = \frac{Rg}{4n}\left(\frac{DP}{4L} - \frac{4}{3}t_y + \frac{64t_y^4L^3}{3D^3p^3}\right) \quad (7)$$

The last term is necessary to obtain accurate values only when V is small; for larger values it may be omitted with negligible error. The equation then becomes:

$$V = \frac{gD}{8n}\left(\frac{DP}{4L} - \frac{4}{3}t_y\right) \quad (8)$$

$$P = \frac{16Lt_y}{3D} + \frac{32nVL}{gD^2} \quad (9)$$

Expressing P in the more common units of lbs./sq. in.

$$\Delta P = \frac{Lt_y}{27D} + \frac{2nVL}{9gD^2} \quad (10)$$

The yield value (t_y) and rigidity (n) of a mud can be determined from pipe flow data by plotting $\frac{D\Delta P}{4L}$ as the ordinate and $\frac{SV}{gD}$ as the abscissa. The yield value is then equal to ¾ of the intercept of the straight line portion of the curve on the t_p axis, and the rigidity is equal to the slope of the straight line portion of the curve.

If the yield value and rigidity are known, the complete plastic flow curve for any size pipe can be obtained with Equation 7 and the approximate curve can be obtained with Equations 8, 9, or 10.

Critical Velocity

The apparent viscosity of a mud flowing in any size of pipe at any velocity can be found by equating Poiseuille's equation,

$$p = \frac{32uVL}{gD^2} \qquad (11)$$

with Equation 9 and thus obtaining an expression for the apparent viscosity (u) in terms of yield value and rigidity.

$$U = \frac{gDt_y}{6V} + n$$

It has been experimentally determined by several investigators that the critical velocity for muds normally occurs at a Reynolds number of 2000 to 3000. The critical velocity may be located by substituting the above value for u, setting the new form of Reynolds number equal to 2000 and to 3000 and solving

$$V_c = \frac{1000n + 1000\sqrt{n^2 + \frac{D^2t_y\rho g}{3000}}}{\rho D} \quad (Re = 2000) \qquad (12)$$

$$V_c = \frac{1500n + 1500\sqrt{n^2 + \frac{D^2t_y\rho g}{4500}}}{\rho D} \quad (Re = 3000) \qquad (13)$$

A more accurate calculation of the critical velocity under uniform flow conditions may be made by use of the Fanning equation

$$\Delta P = \frac{4fLV^2\rho}{2gD} \qquad (14)$$

with Equation 9. The resulting equation is also a quadratic with respect to V_c

$$V_c = \frac{8n + 8\sqrt{n^2 + \frac{fD^2t_y\rho g}{24}}}{\rho fD} \qquad (15)$$

Since the Fanning friction factor, f, is dependent on the velocity, the solution of this equation must be made by trial and error.

In actual practice the flow conditions of drilling mud are not uniform due to the use of reciprocating pumps, vibration, drill stem rotation, etc., so that turbulence will usually occur at the lowest critical velocity. Under these circumstances, Equation 12 will probably give results as satisfactory as those obtained by the more elaborate Equation 15.

Turbulent Flow of Plastic Materials

Above the critical velocity the flow of drilling muds is turbulent, or hydraulic, and resembles that of true fluids. Caldwell and Babbitt[9] stated that the familiar friction factor versus Reynolds number chart may be used with the Fanning equation, Equation 14, for turbulent flow of sludges and such similar suspensions, provided the viscosity of the dispersion medium is used.

It was found in the experiments described later in this paper that computations for drilling muds based on this method resulted in pressure drops lower than observed values. Inasmuch as the correct friction factor vs. Reynolds number relationship had been established with water in the writers' experiments for two-inch I.D. pipe, it was possible to compute the effective turbulent viscosity for the muds used in these tests. These viscosities varied from 2.5 to 12 centipoises, instead of being equal to that of water; also, Pigott[6] has shown turbulent viscosities of three and five centipoises, respectively for two common muds. However, it developed that a reasonably good correlation could be drawn between the turbulent viscosity and the rigidity, as shown in Figure 2, even though the data points exhibit a somewhat scattered pattern.

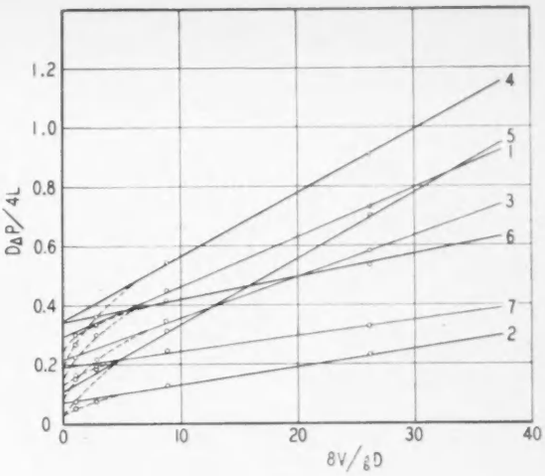


FIGURE 4. Plot of flow data in 20 feet of three-eighths-inch pipe for determination of mud flow constants.

The Reynolds number, as ordinarily expressed for hydraulic fluids, is

$$Re = \frac{DV\rho}{u}$$

For drilling muds, however, the data from Figure 2 suggests that this should be altered to the following empirical relationship

$$Re = \frac{3.2\ DV\rho}{n} \qquad (16)$$

for calculations of critical velocity pressure relations and determination of the Fanning friction factor. Good results were obtained by using this relationship in the Fanning equation for calculations of turbulent flow pressure differentials. Figure 3 shows the friction factor vs. Reynolds number relationship for flow in several types of pipe and in annuli. Curves 1 and 2 were taken directly from Walker, Lewis, McAdams and Gilliland.[11] Curves 3 and 4 were estimated from Pigott's data.

All of the equations given here are applicable to annular flow provided the value 4m, where m is the hydraulic radius, is used in place of D.

$$m = \frac{\frac{1}{4}(D_1^2 - D_2^2)}{(D_1 + D_2)} = \frac{1}{4}(D_1 - D_2) \qquad (17)$$

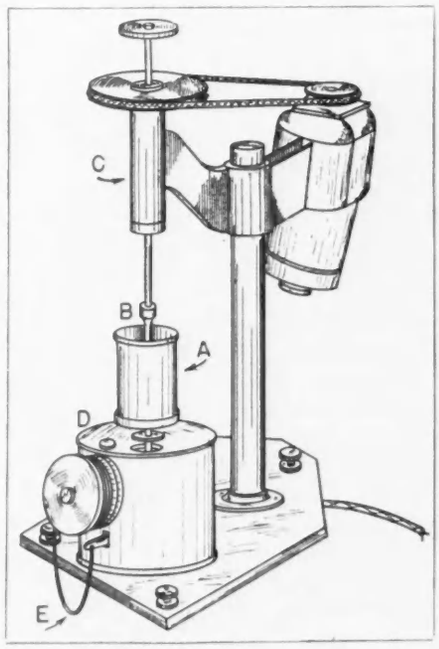
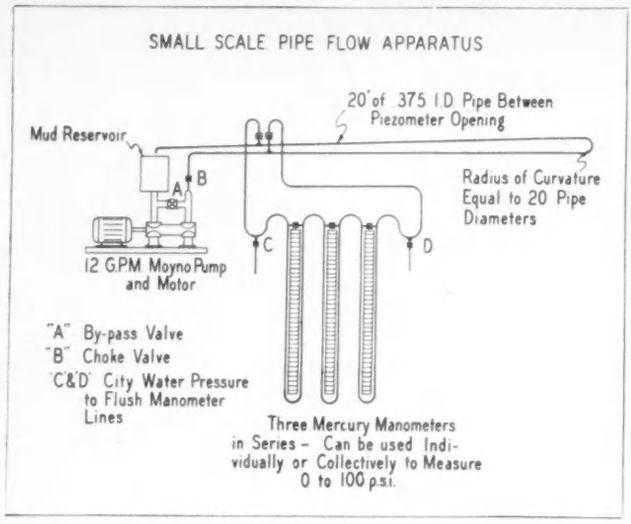
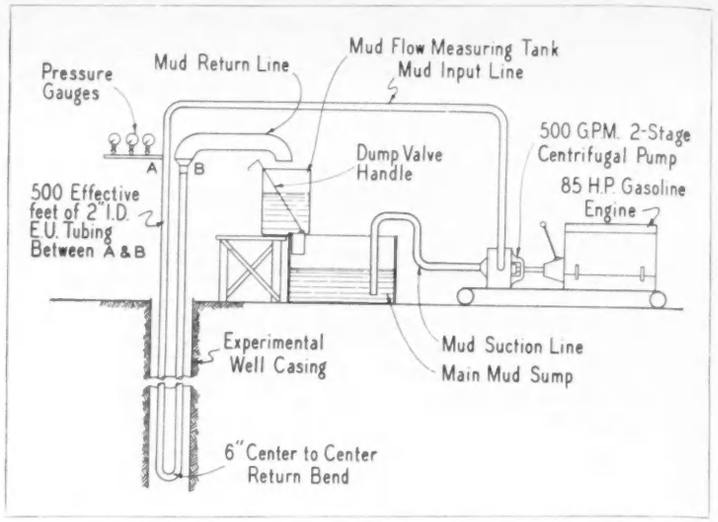


FIGURE 5. The rotational viscosimeter used for drilling muds.

Apparatus for Measuring Mud Flow Constants

Consideration of the advantages and disadvantages of various instruments for determining the necessary mud flow constants for use in plastic flow equations leads immediately to discarding actual pipe flow methods. Pipe flow tests require relatively large scale apparatus and large mud samples, are time-consuming, and require more than one operator. Capillary tube methods were considered since the method is funda-


SMALL SCALE PIPE FLOW APPARATUS
20' of .375 I.D. Pipe Between Piezometer Opening
Mud Reservoir
Radius of Curvature Equal to 20 Pipe Diameters
A
B
C
D
12 G.P.M. Moyno Pump and Motor
"A" By-pass Valve
"B" Choke Valve
"C&D" City Water Pressure to Flush Manometer Lines
Three Mercury Manometers in Series - Can be used Individually or Collectively to Measure 0 to 100 p.s.i.



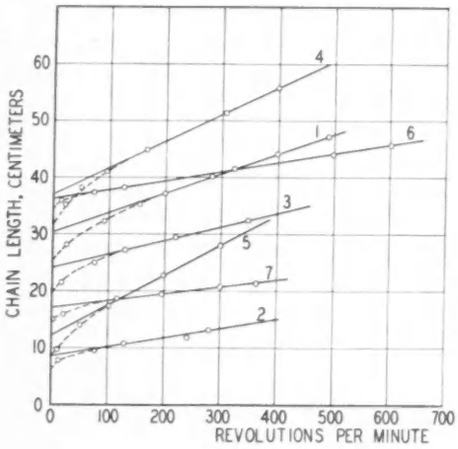


FIGURE 6 (Upper Left). Schematic diagram of three-eights-inch ID pipe flow test.

FIGURE 7 ((Upper Right). Schematic diagram of two-inch ID pipe flow test.

FIGURE 8 (Lower Left). Plot of rotational viscosimeter data for determination of mud flow constants.

mental and has been well developed both in the field of true liquids and for plastic flow measurements. Unfortunately, this method is not entirely suitable for use with drilling muds because of the coarseness of a large part of the suspended phase of the mud. Falling ball viscosimeters were obviously unsuited to drilling muds because the opacity of the mud prevents visual observation of the rate of fall of the spheres. A third method showing most promise involved the use of a rotational viscosimeter.

Several rotational viscosimeters are available commercially; however, none of these is completely suited for drilling mud determinations. Instruments of the McMichael type, in which the outside cup rotates, must operate at low speeds to prevent the fluid being thrown out by centrifugal force. These slow speeds do not allow measurements in the complete flow range. The Stormer type is capable of operation over satisfactory speed ranges, but its baffled cup produces heterogenous flow conditions which are not well suited to mud flow determinations. Also, the short running time of the Stormer does not allow the plastic substance to attain equilibrium flow condition prior to completion of the test.

A modified Stormer viscosimeter which uses a special unbaffled cup, described by Caldwell and Babbitt,[6] is more nearly satisfactory; however, it also suffers from the last-named disadvantage. Wilhelm and Wroughton[7] described a motor driven concentric cylinder viscosimeter, which was not available commercially and which was on somewhat complicated design.

Since none of the commercial viscosimeters was found satisfactory for the study of plastic flow of muds, it was necessary to develop an instrument suitable for this work. The rotational viscosimeter developed for drilling mud flow studies is shown in Figure 5. It consists of a covered cylindrical cup (a), a solid rotor (b), a drill press mechanism for holding and turning the rotor (c), and a mechanism (d) which supports the cup and measures the torque imparted to it by balancing the torque against the weight of a reeled chain (e). In order to reduce friction, the weight of the cup is supported by a cylindrical float in a mercury bath.

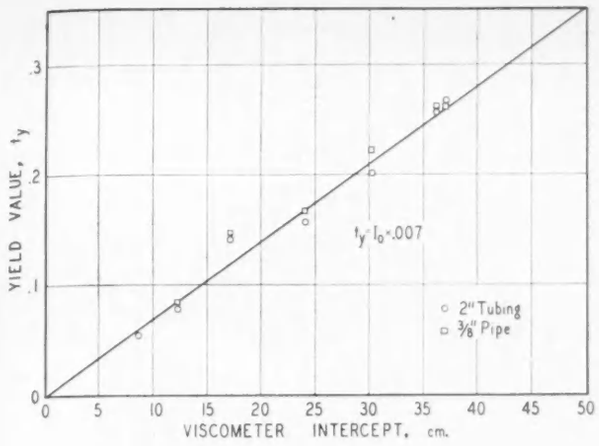
To minimize end effects, the cup and rotor were made long in relation to diameter. The rate of rotation of the rotor is controlled through a range of 0 to 836 revolutions per minute by means of a Graham variable speed transmission. Tests are made by reading the length of chain necessary to balance the instrument at several revolutions per minute values.

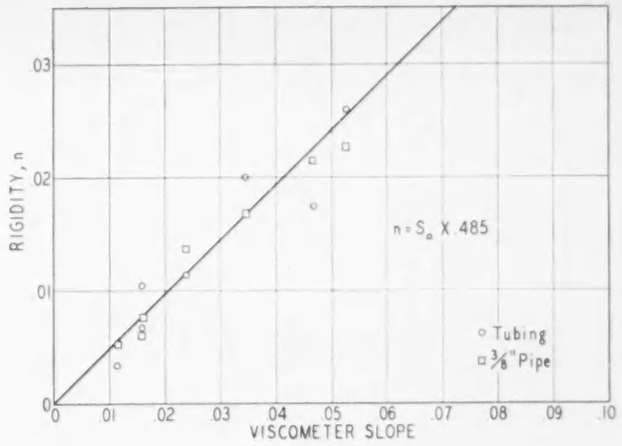
This viscosimeter gave good results in numerous tests and was found to be satisfactory for mud testing.

Calibration of Rotational Viscosimeter

To verify the accuracy of the rotational viscosimeter in measuring mud flow properties, the viscosimetric flow constants for a number of drilling fluids were compared with the flow constants obtained in pipe flow systems, using two sizes of pipe. These systems are shown in Figures 6 and 7.

Seven different muds were prepared and tested on the large and small scale pipe flow set-ups and on the rotational viscosimeter. These muds were especially prepared to have a relatively wide range of yield values and rigidities; their composition is given in Table 1. Calibration of the rotational viscosimeter was accomplished by plotting curves of the intercept and the slope of the torque revolutions per minute curves for the viscosimeter against the mud yield values and rigidities, respectively, as determined in the small pipe flow apparatus. Figure 4 shows flow constants as determined in the small pipe flow apparatus. Figure 8 shows flow curves which were





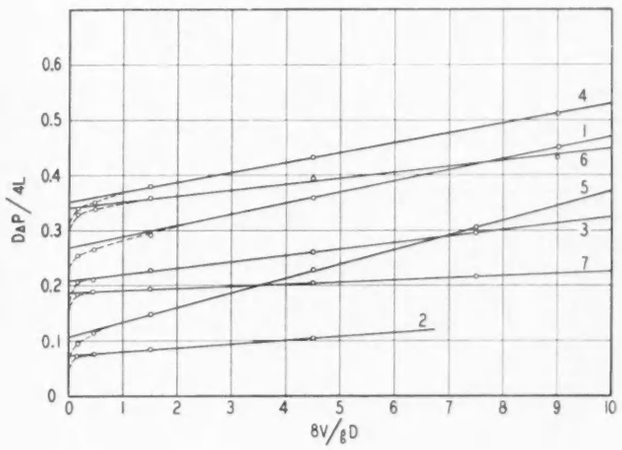


FIGURE 9 (Upper Left). Correlation of rotational viscosimeter curve intercept and yield value, based on pipe flow data.

FIGURE 10 (Upper Right). Correlation of rotational viscosimeter curve slope and rigidity as determined from pipe flow data.

FIGURE 11 (Lower Left). Plot of flow data in 500 feet of two-inch tubing.

obtained from the viscosimeter for the same muds. The latter are simple plots of the revolutions per minute of the rotor against the length of the chain necessary to balance the instrument. Figures 9 and 10 show the calibration of the viscosimeter.

Figure 11 shows the flow curves as determined experimentally in the large scale pipe apparatus. A comparison with curves from small pipe and viscosimeter data indicates that the constants for each mud, as determined by the three methods, are in substantial agreement. The fact that the diameter of the larger pipe is 5.4 times that of the smaller is good evidence that the Bingham yield value and rigidity are independent of pipe diameter.

Figures 12 and 13 show the calculated and observed pressure drop vs. velocity curves for two of the seven muds in the two-inch tubing. The other five muds showed comparable correlations between computed and observed pressure drop velocity curves. The average deviation of viscosimeter values from observed was five percent. The average deviation between observed values for the same pipe was three percent. It can be seen readily from these data that the accuracy obtainable with the rotational viscosimeter approaches the accuracy of the pipe flow apparatus. Using the flow constants for each of the seven muds as determined from the small pipe and the viscosimeter, the computed flow curves shown on these graphs were obtained as follows:

1. The critical velocity for each of the muds in two-inch pipe was computed from Equation 12.

2. The pressure drops for each of the muds at three different velocities below the critical were computed from Equation 9.

3. For each mud, the Reynolds number was calculated at two velocities above the critical by means of Equation 16 and the corresponding friction factor was determined from Curve III of the friction factor Reynolds number chart shown in Figure 2. The pressure drops at the two velocities above the critical were then calculated by Equation 14.

4. The flow curve for water in the two-inch tubing was placed on each graph for orientation purposes.

The calculated curves are based on data from the rotational viscosimeter and pipe flow tests through 20 feet of ⅜-inch I.D. pipe. The observed curves were plotted from pipe flow tests through 500 feet of 2-inch I.D. tubing. Most of these curves agree very closely, showing clearly that the pipe flow constants used in Bingham's equation of plastic flow are independent of

TABLE 1
Mud Composition

Mud No. 1
6.5 percent bentonite slurry.
Density = 8.66 lbs./gal.

Mud No. 2
4.5 percent bentonite slurry.
Density = 8.58 lbs./gal.

Mud No. 3
4.5 percent bentonite slurry weighted with barium sulfate.
Density = 10.93 lbs./gal.

Mud No. 4
4.5 percent bentonite slurry weighted with barium sulfate.
Density = 12.39 lbs./gal.

Mud No. 5
4.5 percent bentonite slurry weighted with barium sulfate and treated with .25 lb. of sodium acid pyrophosphate per barrel.
Density = 12.30 lbs./gal.

Mud No. 6
28.3 percent El Paso clay slurry.
Density = 10.0 lbs./gal.

Mud No. 7
26.9 percent El Paso clay slurry.
Density = 9.66 lbs./gal.

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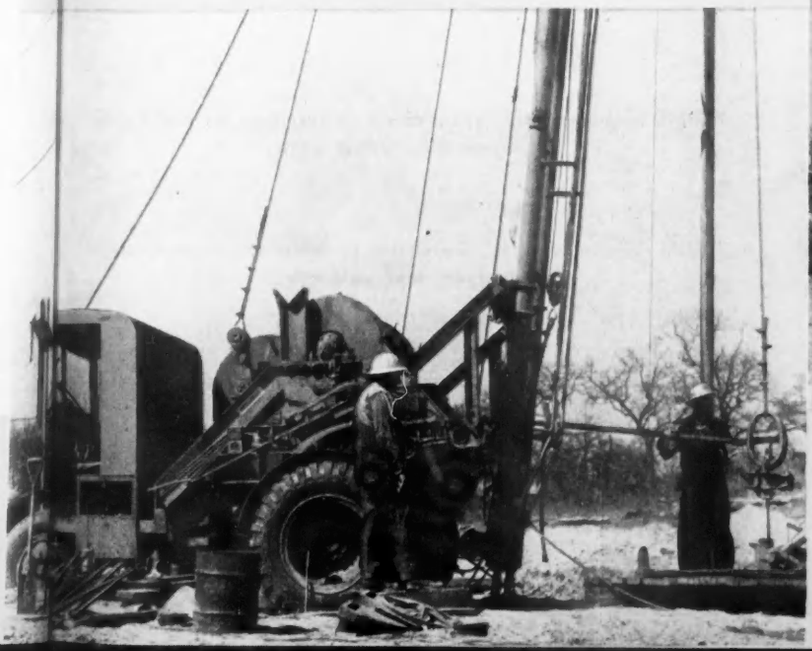
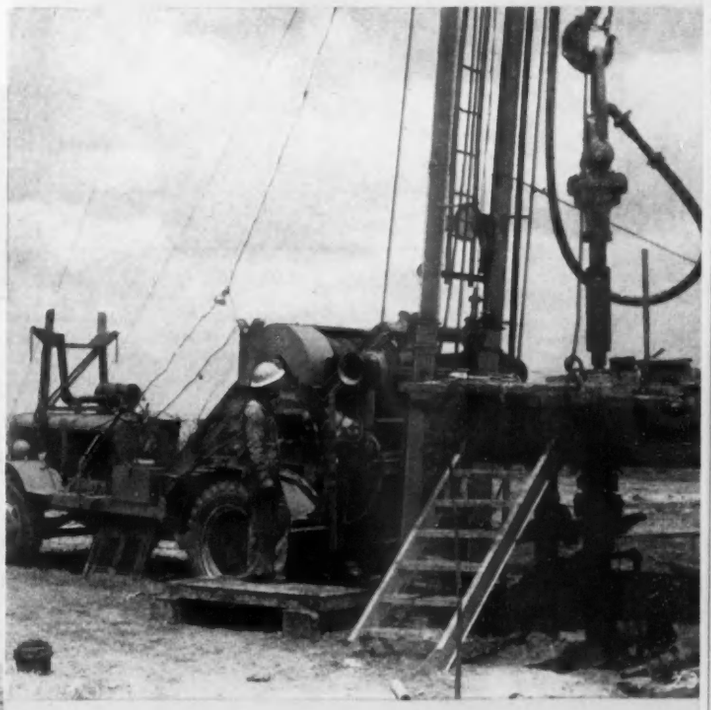
- 35 m. p. h. road speed — four-wheel hydraulic brakes.

Well servicing is fast and profitable because the wide range of operating speeds and air-controlled friction clutches speed up every job. Note how adjustable controls enable operator to work as one of the crew.

Mobilhoist with jerkline spudder assembly deepening a 3,300-foot well in Oklahoma. Air-disc friction clutches in both drums give fast, positive engagement.





A fast, economical workover job using a Mobilhois with rotary table drive assembly. Well was deepenec with 2⅞" drill pipe. Rig-up with 55-foot double leg mast was accomplished within two hours.

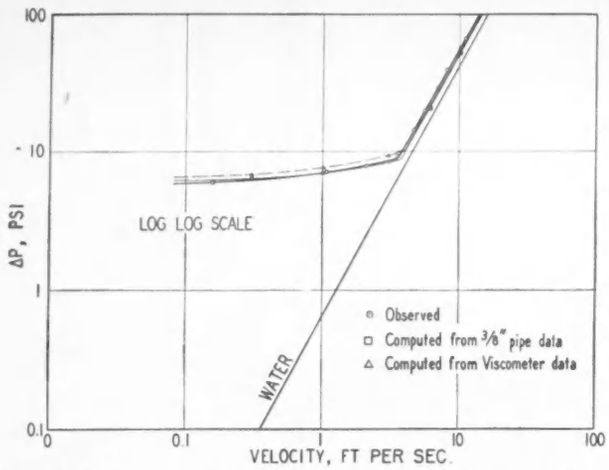


FIGURE 12. Pressure-velocity relationship as determined in pipe flow test and as calculated from viscosimeter data for mud No. 2.

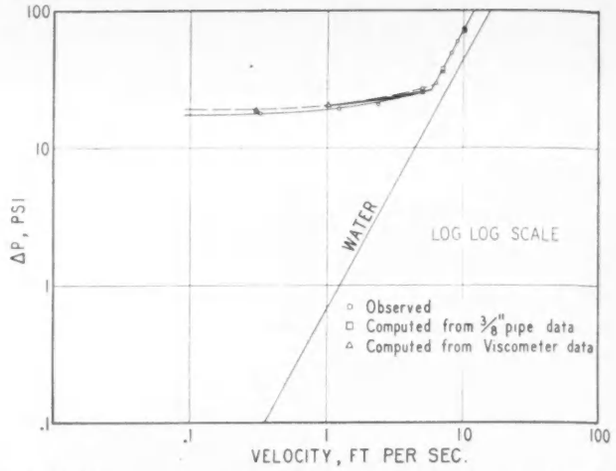


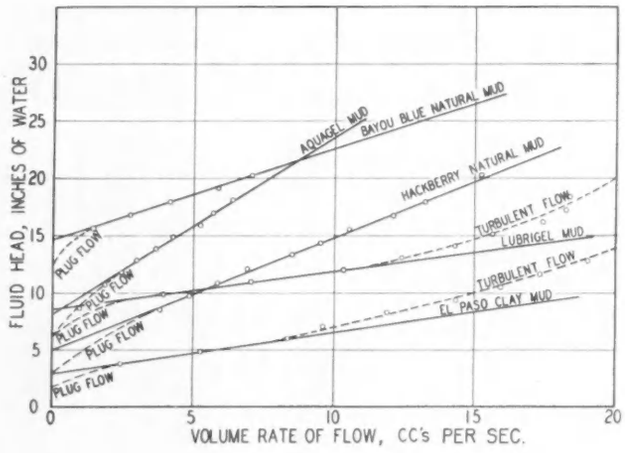
FIGURE 13. Pressure-velocity relationship as determined in pipe flow tests and as calculated from viscosimeter data for mud No. 3.

pipe diameter. Also, the agreement between observed and computed flow data in the turbulent range indicates that the Reynolds number for drilling muds, as calculated in Equation 16, is essentially correct.

Simplified Field Instrument

Upon completion of this portion of the investigation, the rotational viscosimeter was used in a nearby field to determine and control the flow properties of mud on some 20 wells. While good results were obtained in this survey, it was evident that use of the rotational viscosimeter as a field instrument would lead to difficulties in packing and shipping, and in finding trained personnel at the well to operate the instrument. Several different types of simpler apparatus for the determination of yield value and rigidity were designed and tested for reliability and ease of operation under field conditions. The instrument which proved best under such conditions consisted of a funnel type viscosimeter with a brass efflux tube of .185 inch I.D. by six-inch length extending horizontally from the base of the funnel. Since it is necessary to determine the volume rate of flow vs. the head, the body of the funnel is made of lucite plastic so the falling mud meniscus may be observed. The brass tube is mounted horizontally at the base of the funnel to eliminate excessive fluid head. The side of each funnel is marked off in one-inch intervals and the volume in cubic centimeters as well as the mean hydrostatic head of each head interval is determined.

In the operation of the funnel, the efflux tube is plugged with a cork and



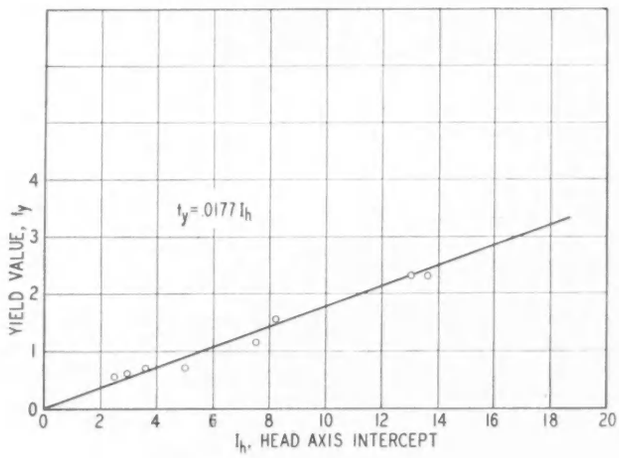


FIGURE 14 (Upper Left). Typical curves obtained from the mud funnel viscosimeter for various muds.

FIGURE 15 (Upper Right). Correlation of funnel viscosimeter curves intercept and mud yield values.

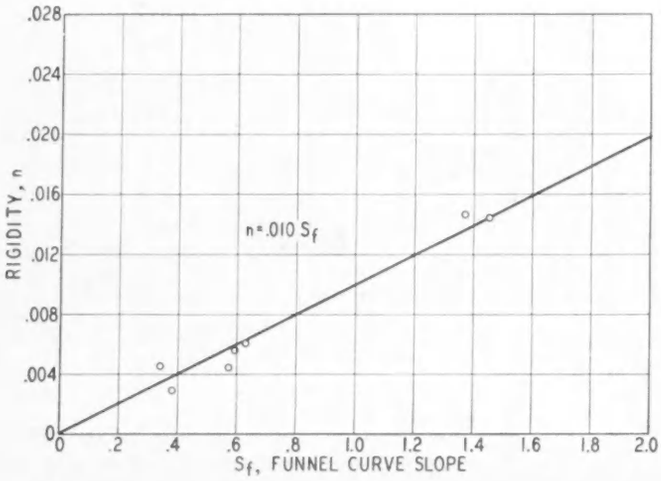


FIGURE 16 (Lower Left). Correlation of funnel viscosimeter curve slope and mud rigidity.

the funnel is filled to above the top interval mark. The cork is then removed and the time at which the mud meniscus passes the first and each successive head mark is recorded.

The volume rate of flow and average head of water for each interval are then determined. The volume rate of flow for each interval in cubic centimeters per second is then plotted as the abscissa against the average head in inches of water for the interval as the ordinate. The resulting curve is a typical flow curve, which may exhibit either turbulent or plug type flow as well as laminar flow. Typical curves taken with the funnel viscosimeter are shown in Figure 14. The laminar flow portion can be recognized as the straight portion of the curve which has a lower slope than either plug or turbulent flow regions.

The funnel viscosimeter has been calibrated as a relative rather than an absolute viscosimeter, because of the difficulty of correcting for the end effects of the short flow channel and because of the minor pressure drops which take place in the funnel itself. A correlation between the intercept of the laminar flow part of the flow curve on the head axis, and the yield value of the mud, as determined on the rotational viscosimeter, is shown in Figure 15. Correlation of the slope of the laminar flow portion of the curve and the rigidity, as determined on the rotational viscosimeter, is shown in Figure 16.

Several of these funnels have been used successfully in the field but as yet no extensive application of the instrument has been attempted. The mud flow funnel is not as accurate as the rotational viscosimeter and also requires considerable amounts of mud, precluding its use as a laboratory instrument.

Practical Applications of Mud Flow Data

As previously mentioned, a knowledge of the flow properties of drilling fluids can be applied to advantage in many drilling problems. For example, in some Gulf Coast wells the fluid pressure in the formations is only slightly less than the overburden pressure and, as a consequence, the wells will sometimes lose mud to the formation while mud is circulating and be in danger of blowing out when circulation is stopped. This may be explained by the fact the pressure drop, due to flow of mud in the well annulus, approximates the difference between the formational and overburden pressures. An obvious solution to such a problem would be to modify the mud properties so as to decrease the pressure drop due to annular flow. This can usually be accomplished by lowering the yield value of the mud. By the proper application of mud flow data it should be possible to devise programs for mud properties, hole size, and drill pipe, which will minimize lost circulation problems in areas known to be troublesome.

Typical calculations of static and circulating bottom hole pressure are shown. Dimensions of pipe and hole and pumping rate are as follow:

Diameter of hole	11 in. or .917 ft.
Outside diameter of drill pipe	4½ in. or .375 ft.
Circulating rate	450 gallons/minute
Well depth	5000 ft.

The mud characteristics are as follows:

Density	10.0 lbs./gal. or 75 lbs./cu. ft.
Yield value t_y	.40 lbs./sq. ft.
Rigidity n	.01 lbs./sec. ft.

The value of 4m for the annulus is calculated by Equation 17.

$$4m = (.917) - (.375) = .542'$$

The critical velocity is calculated by Equation 12.

$$V_c = \frac{1000(.01) + 1000\sqrt{(.01)^2 + \frac{(.542)^2(.40)(75)(32)}{3000}}}{(.542)(75)} = 10.5 \text{ ft./sec.}$$

The actual annular velocity at 450 gallons per minute is found to be

$$\frac{(450)(231)(4)(144)}{(60)(1722)(\pi)(11^2 - 4.5^2)} = 1.83 \text{ ft./sec.}$$

Therefore, the flow is laminar and the pressure drop due to flow is calculated by means of Equation 10.

$$\Delta P = \frac{(5000)(.40)}{27(.542)} + \frac{(2)(.01)(1.83)(5000)}{(9)(32)(.542)^2} = 140 \text{ pounds per square inch}$$

The pressure due to fluid head is

$$(5000)(.434)(10.0)/8.33 = 2605 \text{ pounds per square inch}$$

and the total circulating bottom hole pressure is:

$$2605 + 140 = 2745 \text{ pounds per square inch}$$

A pressure differential of 140 pounds between flowing and static bottom hole pressure could easily be sufficient to cause serious trouble.

Over-All Pressure Drop

In connection with an actual field trial of an oil-base mud it was desired to compute the over-all pressure drop in the drilling well. Typical computations follow:

Tests made at the well with the mud flow funnel indicate that the oil-base mud had a yield value, t_y, of .0885 lbs./sq. ft, and rigidity, n, of .07 lbs./sec. ft. The density of the mud was 10.6 lbs./gal. or 79.4 lbs./cu. ft. Dimensions of the mud pump, hole, and drill pipe are as follows:

Diameter of liner	6¾ in. or .562 ft.
Diameter of piston rod	2½ in. or .208 ft.
Length of stroke	18 in. or 1.5 ft.
Diameter of hole	6-4/10 in. or .533 ft.
Outside diameter of drill pipe	3½ in. or .292 ft.
Inside diameter of drill pipe	2⅞ in. or .24 ft.
Well depth	6880 ft.
Cross sectional area of annulus	.156 sq. ft.
Cross sectional area of drill pipe, I.D.	.045 sq. ft.
Hydraulic radius, m, of annulus	.0603 sq. ft.
4m, annulus	.241 sq. ft.

The volume of mud pumped per cycle of pumps is thus:

$$1.S \times \frac{2\pi}{4}[(.562)^2 + (.562)^2 - (.208)^2] = 1.384 \text{ cu. ft./cycle}$$

and the velocities in the drill pipe and annulus at 24 cycles per minute and 85 percent pump efficiency are:

$$\frac{(1.384)(24)(.85)}{(60)(.045)} = 10.5 \text{ ft./sec. in drill pipe}$$

$$\frac{(1.384)(24)(.85)}{(60)(.156)} = 3.02 \text{ ft./sec. in annulus}$$

The critical velocity in the drill pipe is calculated using Equation 12.

$$V = \frac{(1000)(.070) + 1000\sqrt{(.070)^2 + \frac{(.241)^2(.0885)(79.4)(32)}{3000}}}{(.241)(79.4)} = 8.6 \text{ ft./sec.}$$

The actual velocity in the drill pipe is higher than the critical, so the flow is turbulent, while the actual velocity in the annulus is lower than the critical velocity, resulting in laminar flow in the annulus. The pressure drop in the drill pipe is therefore calculated by means of Equation 14. The pressure drop in drill hole and kelly is accounted for by adding 120 feet to the length of drill pipe.

The Reynolds number is calculated by Equation 16.

$$Re = (3.2)(.24)(10.5)(79.4)/(.07) = 9150$$

Table 2

Pump Speed CPM	Estimate Pump Eff.	Annular Velocity Ft./Sec.	Drill Pipe Velocity Ft./Sec.	ΔP Annulus psi	ΔP Drill Pipe psi	ΔP Total psi	ΔP Observed psi	Percent Deviation From Observed psi
16	.91	2.15	7.47	217	552	769	800	−3.9
20	.88	2.60	9.03	243	776	1019	1000	+1.9
24	.85	3.02	10.50	266	1019	1285	1250	+2.8
28	.82	3.39	11.75	288	1240	1528	1450	+5.4

From Curve 3, Graph 14, the friction factor, f, is found to be .0092 and the pressure drop from Equation 14 is

$$\Delta P = \frac{(4)(.0092)(7000)(10.5)^2(79.4)}{(2)(32)(.24)(144)} = 1019 \text{ psi}$$

The pressure drop in the annulus is calculated by means of Equation 10 using 4m in place of D.

$$P = \frac{(6880)(.0885)}{(7)(.241)} + \frac{(2)(.070)(3.02)(6880)}{(9)(32)(.241)^2} = 266 \text{ psi}$$

The total computed pressure drop is $1019 + 266 = 1285$ psi. This compares well with the observed mud pressure of 1250 psi.

The observed and computed mud pressures on this well for three other pump speeds are as follows:

Similar tests were made for drilling wells in several widely scattered fields. Total over-all pressure drops in the drilling well as computed from flow properties determined with the viscosimeter agreed well with measured pressure drops. Since total pressure drops agree there is added assurance that pressure drops within various parts of the circulating system can be computed with equal accuracy.

At a southern Louisiana well, no data were taken as to dimensions of drill collars, which generally have a smaller internal diameter and hence higher pressure loss than the same length of pipe. This factor accounts for the low computed pressures at the well.

A summary of the field tests is given in Table 3.

Conclusions

1. The flow characteristics of any drilling mud can be defined in terms of two constants, the yield value and rigidity, which are independent of the dimensions of pipe through which the mud is flowing.

2. It has been verified experimentally that the two constants necessary to define flow properties of muds can be determined with certain types of rotational or funnel viscosimeters.

3. Knowledge of the hydrodynamic properties of muds should prove a valuable tool in the solution of numerous drilling problems.

Table 3
Field Test Results

WELL	Marsh Funnel Visc. Sec.	Water Loss cc per 30 Min.	t_y	n	ρ lb. per Gal.	Type Mud	Calculated Pressure	Observed Pressure	Percent Error
				WEST TEXAS					
A	108	4.4	0.096	0.0156	9.1	Caustic Treated	1193	1100	8.5
	80	4.4	0.124	0.0192	9.0	Caustic Treated	1221	1150	6.2
	75	4.8	0.145	0.0136	9.1	Caustic Treated	1273	1150	10.7
	80	5.7	0.143	0.0182	9.2	Caustic Treated	1345	1200	12.1
	93	4.0	0.204	0.0206	9.3	Caustic Treated	1386	1275	8.7
	86	3.6	0.198	0.0181	9.1	Caustic Treated	1428	1200	19.0
				CENTRAL OKLAHOMA					
B	180	6.2	0.375	0.0192	10.0	Caustic-Que.	1124	1075	4.6
	195	6.0	0.393	0.0192	10.0	Caustic-Que.	1189	1100	8.0
				WEST TEXAS					
C	.....	.....	0.0136	0.0046	10.7	Nat. Mud	411	460	10.6
D	35	.....	0.0182	0.00475	9.2	Nat. Mud	631	590	7
E	42.5	.....	0.068	0.0088	9.3	High pH Caustic-Que.	980.7	900	9
F	33	26	0.0177	0.0054	10.5	Salt Water Imp.	403.5	435	7.3
G	.....	.....	0.0576	0.0102	8.95	Emulsion Jel Oil	251.2	265	5.2
H	.....	.....	0	0.00316	.....	.....	797.5	790	.9
				SOUTHERN LOUISIANA					
I	58	.....	0.272	0.01135	10.0	Gel Chemical	971	1000	5.9
	50	.....	0.293	0.00452	9.9	Gel Chemical	839	950	11.5
	44	.....	0.135	0.00814	9.0	Gel Chemical	749	850	12.5
	48	.....	0.264	0.0073	10.2	Grl Chemical	1008	900	12.0
	45	.....	0.152	0.0091	10.0	Gel Chemical	989	900	10.0
	55	.....	0.294	0.00644	10.1	Gel Chemical	988	1000	0.2
	51	.....	0.239	0.0080	10.1	Gel Chemical	932	900	3.5
	40	.....	0.0354	0.0086	10.1	Gel Chemical	800	900	11.0
	53	.....	0.248	0.0127	10.2	Gel Chemical	874	800	9.3
	46	.....	0.159	0.00965	10.2	Gel Chemical	889	950	6.3

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Nomenclature

A = shearing stress (at the pipe wall), poundals per sq. ft.

a = yield value or shearing stress necessary to overcome the internal friction, poundals per sq. ft.

D = pipe or tubing diameter, ft.

D_1 = outside diameter of annulus, ft.

D_2 = outside diameter of drill pipe, ft.

f = Fanning friction factor

g = acceleration of gravity, 32.2 ft./sec.^{2}

L = pipe or tubing length, ft.

m = hydraulic radius of the annulus, ft.

n = rigidity, lbs./sec. ft.

P = pressure drop, lbs./sq. ft.

ΔP = pressure drop, lbs./sq. in.

R = pipe or tubing radius, ft.

Re = Reynolds number

ρ = fluid density, lbs./cu. ft.

t_s = shearing stress, lbs./sq. ft.

t_y = yield value, lbs./sq. ft.

u = viscosity, lbs./sec./ft.

$\frac{U}{t}$ = volume rate of flow, cu. ft. sec.

V = mean flow velocity, ft./sec.

V_c = critical velocity, ft./sec.

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Causes and Prevention of Drill Pipe and Tool Joint Troubles

By H. G. TEXTER
Spang-Chalfant, Inc., and
R. S. GRANT
Hughes Tool Company.
Revised by H. G. TEXTER, Chief Field Engineer, Spang-Chalfant Division of The National Supply Company, and S. C. MOORE, Product Engineer, Hughes Tool Company

THIS IS THE FIFTH of a series of articles which describes causes of drill pipe and tool joint troubles and practical ways of preventing them. The preceding four installments have discussed drill pipe troubles. The discussion of tool joint troubles begins with the current chapter.

The series revises a widely acclaimed paper presented under the same title before the American Petroleum Institute's Twenty-Second Annual Meeting at San Francisco on November 6, 1941. To give readers both the new thoughts on the subject and also the benefit of the very thorough discussion presented in the original manuscript, the old text is reprinted in full in our standard type face and the revisions indented in larger type. The effective revision date is August, 1948.

Reprints of the series in pamphlet form will be available following completion of publication in WORLD OIL. Those desiring reprints should request copies as soon as possible.

Part 5 TOOL JOINTS

MOST of the troubles ordinarily encountered with tool joints were discussed in some detail in a paper entitled "Drill Stem," by H. W. Fletcher.[2] Although the tool joint section of this paper unavoidably repeats some of the same subject matter covered by that author, it is devoted mainly to some of the more recent developments in this category.

In considering present day difficulties with tool joints, two major problems are definitely outstanding, viz.: wabble failures in the pin and box connection, and wear on the outer surface of the joints.

In the earlier days of rotary drilling neither of these caused troubles of any serious consequence; but the increased depth of wells, the use of lighter drilling weight, anti-friction rock bits, higher rotary speeds, etc., have caused a sharp increase in the importance of these tool joint troubles during the past few years.

Several other types of trouble which were encountered with tool joints in the earlier days have been eliminated almost entirely through improvements in material and manufacturing methods. However, in spite of these improvements, some of these troubles still occur on occasion and, therefore, will be discussed rather briefly. A discussion in greater detail then will follow concerning the more pressing problems.

1. Longitudinal Splitting of Tool Joints

1-a. Split Pipe Ends

This type of failure is usually due to seams or non-metallic streaks in the steel. Failures of this type, however, have become almost non-existent due to the increased use of upset forgings in the manufacture of tool joints. This forging or upsetting operation subjects the steel to such drastic deformation that any seams or streaks which may be in the steel usually appear as serious defects in the forgings, with the result that the material is scrapped before being made into tool joints.

1-b. Split Pin and Box Ends

Swelling of tool joint boxes, accompanied by longitudinal splitting, has occurred in a few cases due to the application of exceptionally high torsional loads to the joints, with normal lubrication on the threads and shoulders.

With normal pin-and-box lubrication such as is used during ordinary drilling operations, the friction coefficient in the threads and shoulders is low. Under these conditions, if the joints are subjected to unusually high torque, such as might occur while fishing for stuck drill pipe, the joints may fail to develop the full torsional strength of the pipe section and may result in swelling of the boxes, swedging of the pins, shearing of the pin shoulders, and in ultimate splitting of the boxes, as shown in Figures 31 and 32.

In a few rare cases, failures of another type have occurred as a result of excessively high torque. It should be understood that as a tool joint is made up, that the compression load increases on the shoulders, and the tensile and torsional loads increase in the pin. If the pin is weak, compared to the compressive strength of the shoulder, then it may fail before the shoulder swells and splits. Such a failure is illustrated in Figure 33, in a tool joint designed specifically to have a large bore, at the expense of the strength of the pin.

When exceptionally high torque is to be applied to the drill stem, a special lubricant should be used on the tool joint pin and box connections in order

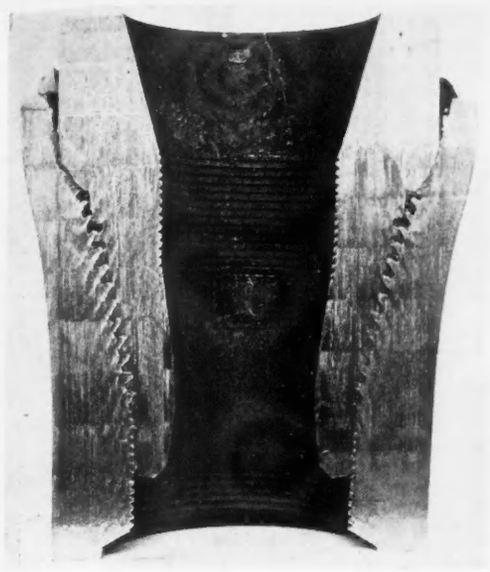

FIGURE 31 (Left)
"Swelled" box and "Swedged" pin resulting from combination of high torque and normal lubrication. Note that pin shoulder has been completely sheared off by the box shoulder.

FIGURE 32 (Right)
"Swelled" tool-joint box showing longitudinal splitting which started at the shoulder.

to develop a high coefficient of friction in the threads and shoulders. For this service a lubricant consisting of 1 to 2 pounds of red lead per gallon of kerosine has been found satisfactory. However, special care should be taken to clean the threads thoroughly before application of this lubricant—not only to remove the lubricant previously used, but also to avoid "frozen" or "galled" joints which might result due to the comparatively poor lubricating properties of the red-lead-kerosine mixture. This material should be used temporarily, only, when high torque is required for a special job.

2. Galled or "Frozen" Tool-Joint Pin and Box Threads

This type of failure, an example of which is shown in Figure 34, is more prevalent in new joints, and usually occurs during the "breaking-in" period. After tool joints have seen some service, the pin and box connections undergo certain changes which result in a material increase in the resistance to galling. Although the exact nature of these changes is not known definitely, one factor of considerable importance should be pointed out, viz., that increased clearance between mating threads resulting from wear provides additional space into which foreign matter can be forced during makeup and, therefore, may reduce galling from this cause.

Although the factors which may contribute to this type of failure are rather numerous, it is frequently difficult to determine the cause exactly from an examination of the damaged pieces. It may be well, however, to discuss some of these factors and point out precautions which can be taken to help in the prevention of this type of trouble.

2-a. Damaged Threads

Tool joint threads frequently became damaged in handling the pipe, particularly if not given adequate protection by the use of substantial thread protectors. The increased use within recent years of thread protectors on tool joints, both in shipment of new joints to the field and in moving the pipe from one location to another, has resulted in a substantial decrease in galled thread failures.

As a precautionary measure to avoid

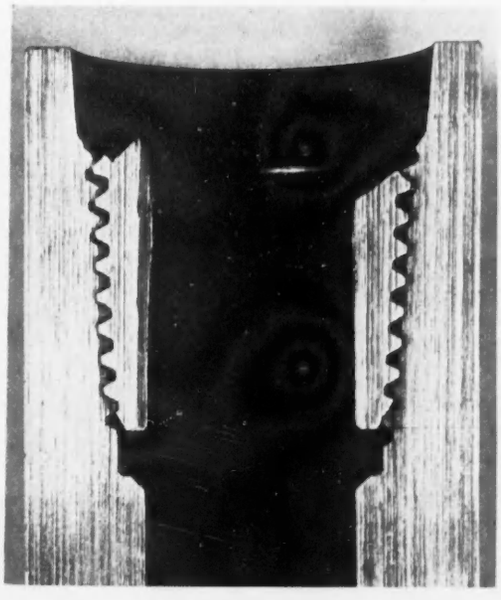

FIGURE 33 (Left)
Tool joint pin which failed in combined torsion and tension due to excessively high torque. Such failures occur in special design tool joints in which the bore has been made large at the expense of the strength of the pin.

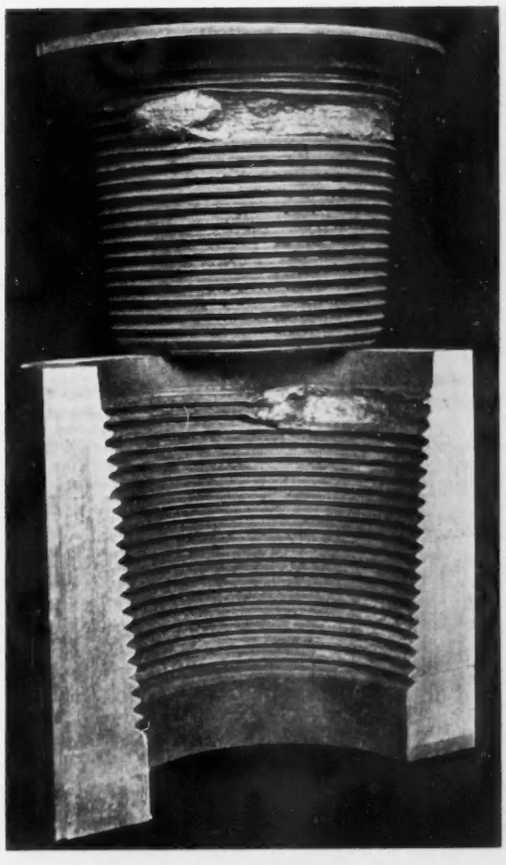

FIGURE 34 (Right)
Example of galled tool-joint pin and box threads which may occur when proper care and attention are not exercised in handling the joints.

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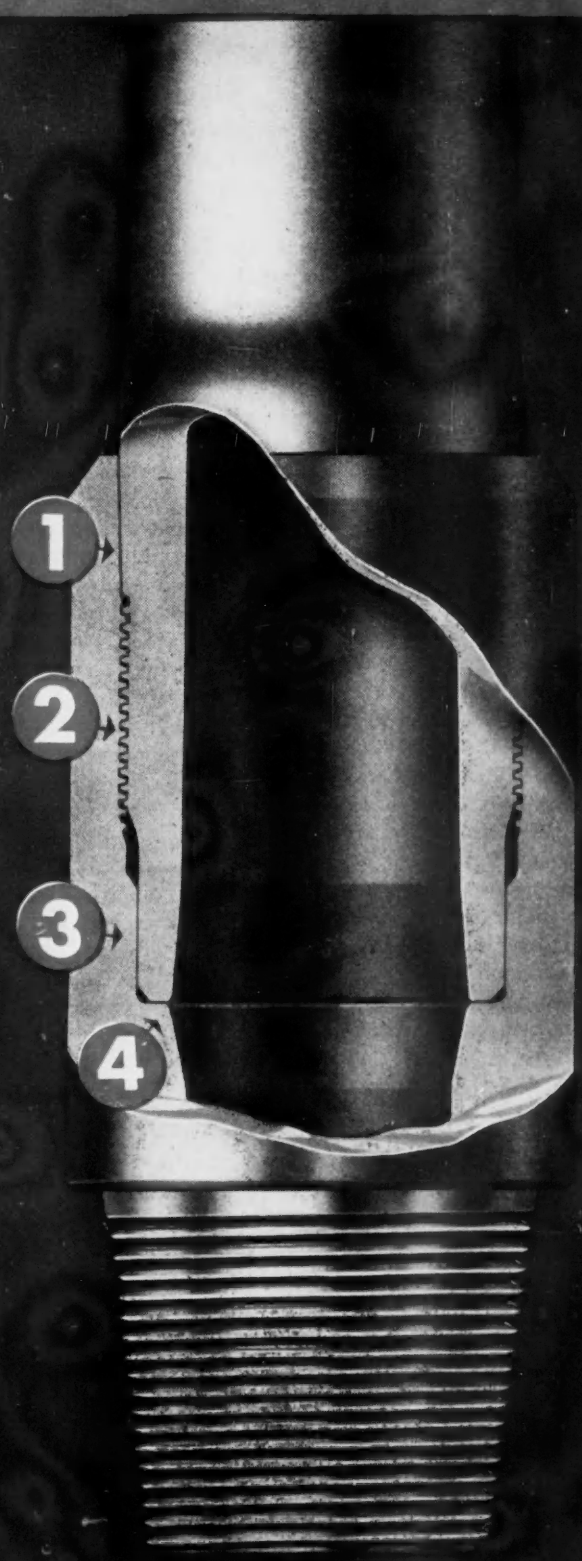

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FIGURE 35
Galled tool-joint pin resulting from forced makeup with improperly engaged threads. Note damage to crests at left of badly galled thread.

galled threads from this cause, it is well to follow the practice of thoroughly cleaning and inspecting the threads and shoulders each time the joints are picked up at a new location. Slightly damaged threads and shoulders should be repaired at the rig by carefully filing off the bruises, and more seriously damaged joints should be repaired in a well-equipped machine shop.

2-b. Lubrication

During the makeup and breakout of tool joint pin and box connections, very high compressive loads often occur on the flanks of the threads. Therefore, unless a good quality of thread lubricant is used, galling is likely to result due to breakdown of the lubricating film under these high loads. Many excellent lubricants have been compounded especially for this purpose, the most satisfactory being those containing finely powdered metals or metal oxides such as zinc or red lead mixed with high quality greases. The powdered materials provide some protection against galling, even though the pressures involved may be so high as to result in breakdown of the grease film.

The lubricants containing finely powdered metallic lead are finding favor because of their low frictional qualities, and because lead smears into a thin protective film between the steel surfaces. Low frictional characteristics are desirable because tighter connections can be obtained for a given buck-up torque. On the other hand, low friction may be a disadvantage if exceptionally high operating torque is encountered, as mentioned under section 1-b.

Very good results also have been obtained with the use of special lubricants containing, in addition to powdered red lead, a relatively soft, easily compressed filler of rather coarse particle size, such as cottonseed meal, sifted to pass through a 12-mesh screen. This coarse filler becomes tightly compressed in the threads when they are screwed together and, therefore, provides an effective sealing action in the threads which is not provided in the case of many other lubricants commonly used on tool joint threads. This material has been found to be very effective as a gall preventive even under high loads, and there is also some evidence to indicate that it assists in preventing the joints from "vibrating" loose while in service.

It is now considered best practice to use one of the metallic base lubricants on new tool joints. Experience indicates that they have better gall resistant properties than lubricants containing other fillers. After tool joints have seen considerable service and become troublesome from leakage due to damaged shoulders, the lubricants containing such fillers as cottonseed meal are recommended.

As additional protection against galling of threads and shoulders, the lubricant should never be allowed to become contaminated with sand, drilling mud or other abrasive material—and the connections themselves should be cleaned well and adequately lubricated. In applying the lubricant, care should be taken to see that it is applied to the full length of threads and to the shoulders as well. Rotation of the pin in the box during makeup should not be depended upon to distribute the lubricant in the connection. A radial-bristle brush similar to a bottle brush has been found satisfactory for applying the lubricant to tool joint threads.

2-c. High-Speed Makeup

It is common practice to make up tool joint connections with a spinning line, which often develops high rotational speeds. Generally this practice does not cause trouble on old or worn joints; but if used with new joints, where the thread fit is much tighter and the thread surfaces have not become cold-worked, it frequently results in "burned" or galled threads. For the first two or three round-trips it is safer to tong the joints up by hand, and then cathead them up tight in the rotary, rather than to use the spinning line, as the danger of galling thereby is reduced.

2-d. Forced Makeup of Threads Improperly Engaged

When the tool joint pin is stabbed into the box, the crests of the pin threads frequently land opposite the crests of the box threads, thus resulting in a jamming or wedging of the pin in the box. If the pin is rotated forcibly in the box in the makeup direction under these conditions, damage to the crest of the threads is almost certain to result. This damage is apt to cause a seriously galled connection, as shown in Figure 35.

In the event that this jamming or wedging occurs, it is advisable either to rotate the joint backwards until the threads become properly engaged or to lift the stand and rotate it slightly, then lower it into the box—taking care to see that the threads become properly engaged before attempting to make them up.

2-e. Use of Worn or Damaged Kelly Sub

Inasmuch as the kelly sub is made up into every tool joint box in the string, as hole is drilled, it is particularly important that this item of equipment be kept in good condition at all times. Use of a badly worn or damaged kelly sub may result in damage to many or all of the boxes in the string, and this damage in several cases has been the cause of subsequent galling or "freezing" of tool joint pins and boxes.

2-f. Hardness of Material

The first heat-treated tool joints were manufactured within a hardness range which was considerably wider than that in current use by most manufacturers. These wider limits permitted the use of harder, and also softer, joints than are in general use at this time. It was found through years of experience that galling

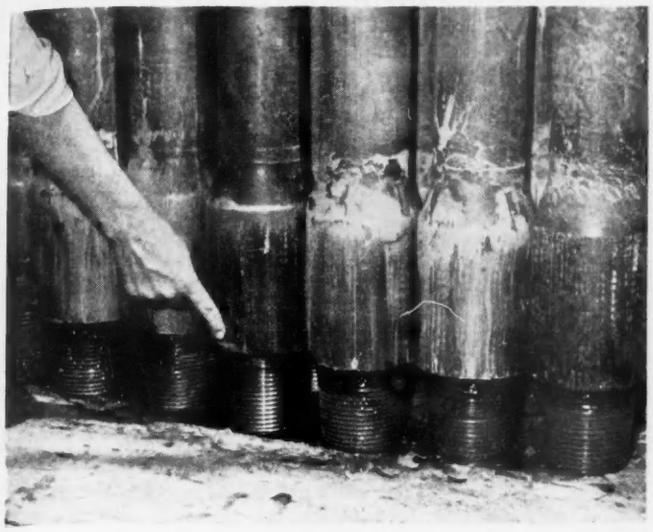


FIGURE 36

Leaky joints are first indication of trouble. The lubricant washes out of loose connections leaving them with an appearance termed "dry" or "muddy."

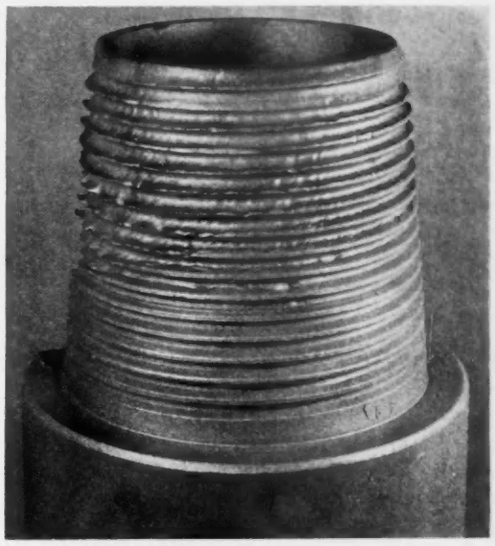


FIGURE 37

Continued operation of loose joints similar to the one in Figure 36 results in a wabble failure of the type above. Such failures are usually called "washouts."

was more prevalent in the softer joints, whereas breakage occurred more frequently in the harder joints. Thus, present hardness limits were established by selecting the range of hardness wherein minimum failures of both types occurred. Present methods of controlled heat treatment and close inspection insure a product of uniform hardness at definite control points established by the manufacturers. Furthermore, inasmuch as the hardness usually can be checked accurately on a damaged joint as well as on a new joint, any question on this point can be settled readily.

Several manufacturers are now electroplating the surfaces of tool joint connections with a soft metal, such as copper, to increase resistance to galling during the so-called "breaking-in" period. Several other manufacturers treat these surfaces with a phosphate coating for the same purpose. Such measures have proved very effective for minimizing galling during the early life of the tool joints.

3. Wabble Failures

Failures in tool joint pins and boxes due to wabbling are the result of operation of the connections while loose. These failures developed with changes which were made in drilling practices in order to drill straighter hole.

Analyzing the major changes which have been made to accomplish this, we find that they are—in large part at least—in the direction of reducing the torque and making conditions more favorable for the setting up of transverse vibrations in the drill stem.

In the earlier days of rotary drilling, the use of heavy drilling-weight, plain-bearing rock bits, and a large percentage of fishtail or drag-type bits developed rather high torque in the drill stem. This torque was sufficient so that any joints not actually tight would be made up quickly, and the weight had a tendency to cause the pipe to "spiral" in the hole and thus contact the wall. Contact between the pipe and the wall of the hole serves to prevent the occurrence of transverse vibrations in the drill stem, which have a tendency to cause the joints to work loose.

The change to light drilling weight, and the increased use of drill collars to supply the weight, both increase the length of pipe which is operated in tension. This condition is favorable for the setting up of transverse vibrations in the drill stem because the pipe does not have the same tendency to "spiral" in the hole, but is free to "whip" as it rotates. Also, it seems reasonable to assume that pipe held in tension does not contact the wall of the hole as forcibly as would pipe under compression, in straight hole at least. This would result in a reduction in the friction of the pipe against the wall of the hole and, consequently, a reduction in torque required to rotate the drill stem.

A further reduction of torque has resulted from use of anti-friction bearings in rock bits and a general reduction in the use of fish-tail or drag-type bits. The lower the torque in the drill stem, the less tendency there is to tighten loose joints or to help keep others tight.

Increased tendency of the joints to leak, particularly in view of the increase in pump pressure accompanying increased rates of circulation and the greater depth of wells, has resulted from reduction in mud viscosity. Also, although the effect may be slight, lighter-viscosity mud has less damping effect on vibration of the pipe in the hole than would mud of higher viscosity.

Higher rotary speeds tend to increase the vibration or whipping of the pipe in the hole, especially if the speed used happens to be critical for the particular conditions involved.

3-a. Leaky Joints—"Dry" or "Muddy" Pins and "Washouts"

The earliest indication of wabble-type failures developing in a string of joints is the appearance of "dry" or "muddy" pins. Loose joints naturally are not pressure-tight; therefore, mud works into the connections and displaces the thread lubricant, thus accounting for the "dry" or "muddy" appearance of the pins when the connection is unscrewed.

Leakage resulting from loose joints often develops into badly "mud-cut" joints or "washouts" as shown in Figures 36 and 37.

3-b. Lapped or Worn Threads and Shoulders

When mud cutting is not as serious as shown in Figures 36 and 37, the threads and shoulders often become worn very rapidly as a result of a lapping action, which is set up as the pin wabbles in the box. The shoulders become lapped or worn to the point where they develop a definite crown, wherein high spots usually are found at two points diametrically opposite. These two high spots act as the fulcrum or axis

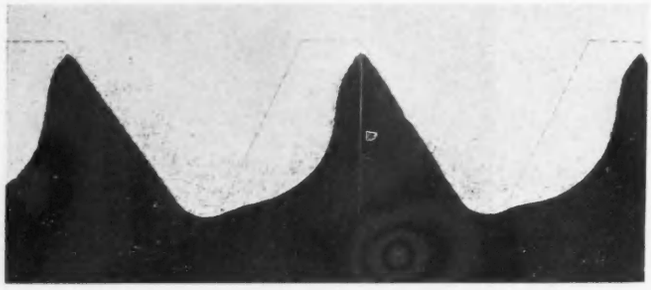


FIGURE 38
Showing maximum wear on pressure flanks of tool-joint threads at 90 degrees to the axis of wabble.

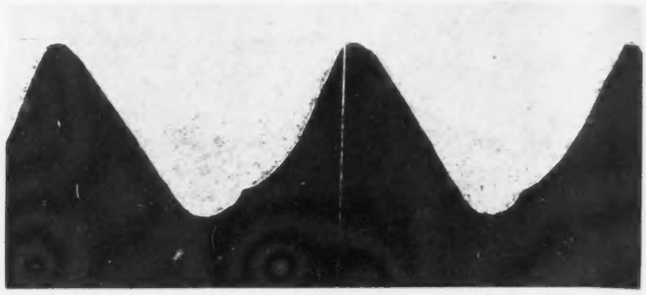


FIGURE 39
Showing minimum wear on pressure flanks of tool-joint threads in line with the axis of wabble.

about which wabbling occurs. Maximum wear on the threads occurs on the pressure flanks at an angle of 90 degrees with the axis of wabble, as shown in Figure 38, while minimum wear occurs along the axis of wabble as shown in Figure 39.

3-c. Broken Threads

As this wabbling operation continues, the threads directly below the axis of wabble often fail in fatigue, due to repeated bending back and forth during each cycle of rotation. Failures of this type are shown in Figures 40 and 41. If the joint is unscrewed at this stage, galled threads frequently occur due to interference of these broken threads, coupled with inadequate lubrication resulting from leakage through the connection.

3-d. Broken Pins and Boxes

The wabbling action also sets up severe stress alternations in the pins and boxes, which alternations often result in formation of fatigue cracks—the cracks usually originating at the root of the threads near the large-diameter end. In extreme cases complete fracture of the pin or box will occur, as shown in Figures 42 and 43.

No changes in design of tool joint connections have been found which will prevent failures of this type. It has been found, however, that they can be prevented by the exercise of care in tightening the joints as they are run into the hole, provided sufficient care also is exercised in handling the pipe to avoid damage to the pin and box shoulders.

A tensile load on tool-joint connections such as that due to the weight of drill stem held in suspension below the connection during drilling results in stretching of the pin. This, in turn, results in separation of the pin and box shoulders unless the joint has been tightened sufficiently to produce an initial compression load between the pin and box shoulders in excess of this weight.

The degree of tightness required has been found to depend largely upon the drilling conditions. When rock bits are used with heavy drilling weight and slow rotary speeds, or when drag bits are being run, a moderate degree of care in catheading the joints up tight is sufficient. On the other hand, when most of the digging is with anti-friction rock bits and light drilling weight, extreme care must be taken to buck every joint up tight when going into the hole. Even after making these precautions, there is some hazard that the joints may loosen during drilling.

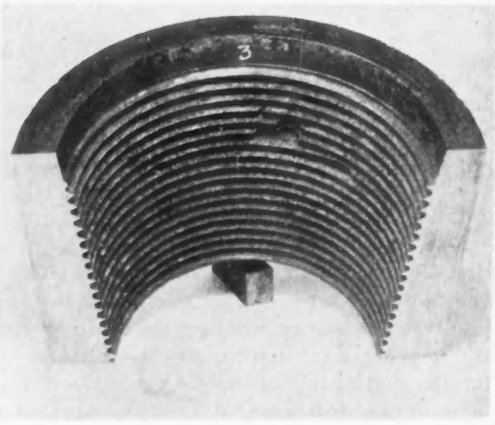
The amount of force required to break the joints apart when coming out of the hole provides a fairly good check of whether they previously were made up sufficiently tight. If they break apart easily, they should be bucked up tighter the next time they are made up, or failures are apt to occur. It is good practice to use at least one wrap of the jerk line on the cathead for each inch of nominal pipe size when tightening tool joint pin and box connections. Thus, three wraps should be used for 3½-inch pipe, 4 wraps for 4½-inch pipe, etc.

Modern automatic type catheads introduce another unknown into the tonging of tool joints. Not even the number of wraps is available as an index of tightness. However, a rule of thumb check can be made by first tightening the tool joint with the automatic cathead, then marking the position of make-up and further tightening manually with the specified number of wraps on the cathead. If additional make-up is obtained, the tonging effort used with the automatic cathead should be increased until this difference is no longer noted.

It is expected that the use of power tongs will reduce "wabble" troubles because

FIGURE 40 (Left)
Broken tool-joint pin threads occurring directly below the axis of wabble.

FIGURE 41 (Right)
Broken tool-joint box threads occurring directly below axis of wabble. Note gall and notch failure on box shoulder in line with the axis of wabble.



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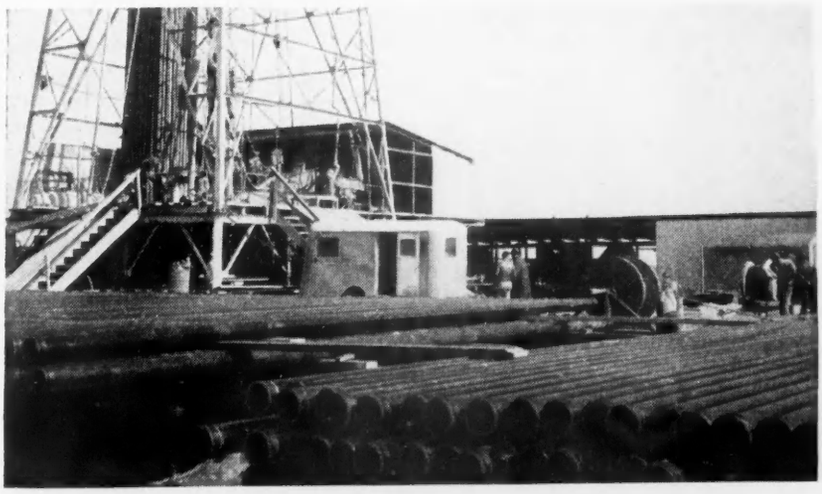

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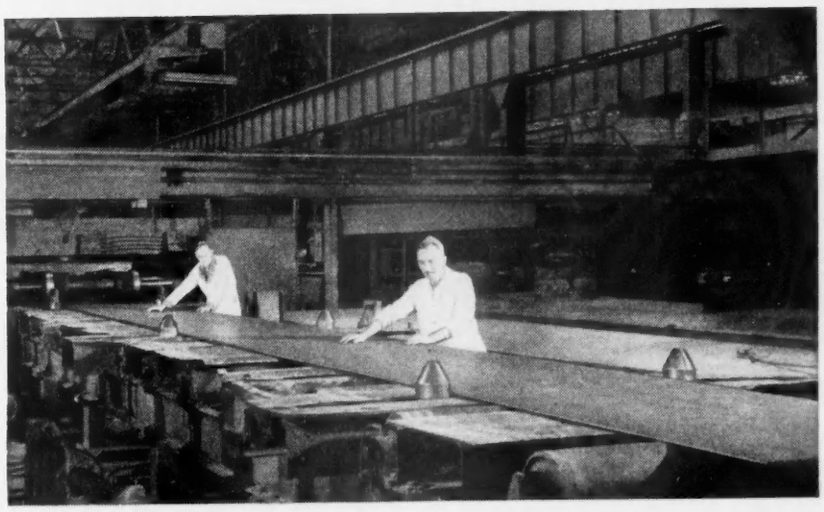

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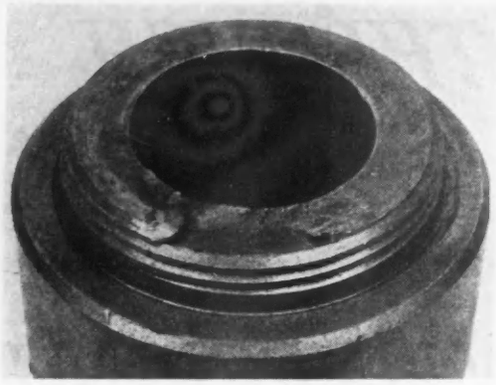

FIGURE 42 (Left)
Fatigue failure in tool-joint pin resulting from wabbling.

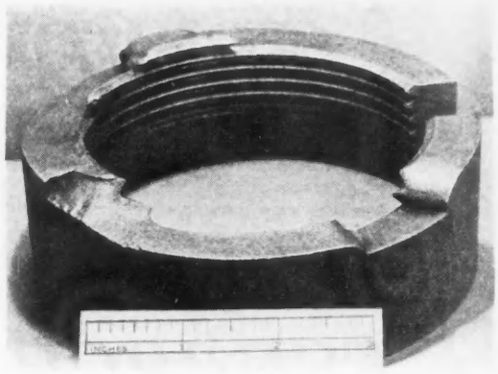

FIGURE 43 (Right)
Fatigue failure in tool-joint box resulting from wabbling.

they can be adjusted directly to provide a specified torque that is sufficient to avoid connections becoming loose in service. This improvement is anticipated because field observations have shown that the great majority of "wabble" troubles have been the result of inadequate make-up torque. Although the figures have not yet been definitely established, suggested make-up torques are listed as follows:

Suggested Make-up Torque for Tool Joints

Nominal Size Inches	*Torque Lbs. Ft.*
2⅜	4,000
2⅞	6,000
3½	10,000
4½	16,000
5½ (Formerly 5 9/16)	22,000
6⅝	28,000

When "dry" or "muddy" pins are found in the string, steps should be taken immediately to correct the trouble. If caught in the early stages, joints which have been wabbling usually can be repaired on the rig by dressing off the shoulders with files until the shoulders are flat. A small, hand-operated dressing tool containing short files, as shown in Figure 44, has been found satisfactory for this purpose. Figure 45 also shows a ring gauge for checking flatness of the shoulders, which ring gauge should be used in connection with the shoulder dressing tool. Unless the shoulders are flat and free from bruises, fins, scores, galls, etc., it is impossible to obtain a uniform bearing around the full circumference, regardless of how tightly the joint is tonged.

A uniform shoulder bearing is essential to prevent stress concentration, leakage, and wabbling. Therefore, the condition of the shoulders should be watched closely, and care should be exercised in handling the pipe to avoid striking the box shoulder with the end of the pin during stabbing or on the rebound when the pin is jumped out of the box with a spring hook. Protection also should be afforded the shoulders, during movement of the pipe, by the use of sturdy protectors.

When a "dry" or "muddy" pin is found, there is often a tendency to switch the dry pin to an undamaged box and put a good pin into the damaged box, in the hope that this will correct the trouble. Instead, however, this procedure usually results in further damage to two joints instead of one—and, thus, if the practice is continued, the trouble may spread throughout the whole string.

(To be concluded next month)

FIGURE 44 (Left)
Hand operated tool joint shoulder dressing tool can be used to face shoulders damaged by galling or early stages of wabble.

FIGURE 45 (Right)
Flatness test gauge being used to check box end shoulder. Both pin and box shoulders must be flat to provide uniform bearing surface.

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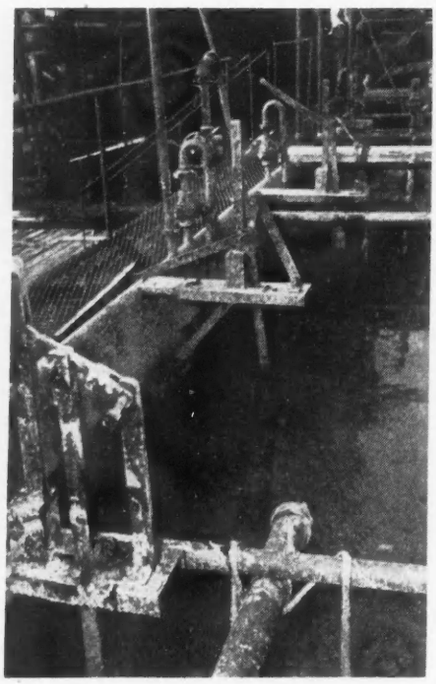
HOW TO—Connect Mud Pump Suction Valves to Elevated Tank

A considerable advantage may be gained by placing the mud pump suction valves connecting the pumps with an elevated mud tank. This arrangement saves the time consumed in tearing down and rigging up if the large valves are located on the outside of the tank; and it protects these valves during rig moves as well as during the time the rig is in operation. A glance at the valve control levers will tell whether or not the valve is opened or closed.

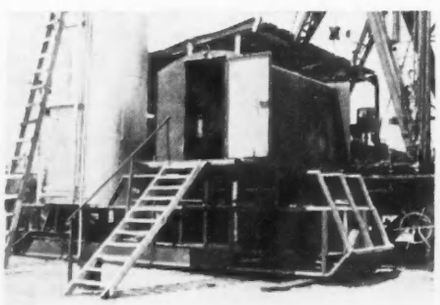
Each valve is of the drop gate type and is screwed into an eight-inch flange which is welded to the mud tank near its bottom. The gate valve stems are connected to the extension arms by means of bolts which permit disconnection in case it is necessary to remove one of the valves for repair. The valve is closed by lowering the gate, and thus lowering the extension arm. Conversely, it is opened by raising the extension arm.



Travel of the valve stem extension is controlled at the top of the tank by a leverage system. The controlling mechanism is mounted on the end of a two-foot section of four-inch channel iron welded and braced to the top edge of the mud tank. A slot was cut near the outer end to receive the strap steel extension arm. A lever of similar strap steel and approximately 30 inches in length is anchored at one end to a ten-inch upright. The extension arm is hinged to the lever by a bolt inserted through the lever about six inches from the end of the lever. Thus, considerable leverage was gained in opening and closing the valve. In order to temporarily position the valve lever, two pieces of strap steel are mounted on a four-inch steel pedestal as shown. The lever operates up and down between the two pieces of steel which contained holes through which pegs could be inserted, thereby holding the lever in position, opened or closed, or any position in between.

HOW TO—Build Multi-Purpose Drilling Rig Utility Rack

A multi-purpose skid base utility rack that speeds setting up and moving is employed by a Wyoming drilling company. Built of salvaged drill pipe and tubing, the all-welded rack resembles a long sled, the front end being higher than the rear. Designed to be set up alongside rigs having relatively low floors, the rack supports the all-steel dog house at the front end, and a tall water tank on the rear, lower deck. Between the "runners" of the sled on the lower-most level, is a space devoted to the storage and carrying of miscellaneous piping and fittings required at each location. A foot-high panel of sheet steel around the sides of this lower compartment prevents the loss of small materials during moving operations.



The storage portion of the rack, being centrally placed at the location, facilitates locating pipe or fittings when needed, and at the same time contributes considerable to the general neatness of the well surroundings. Much time usually spent in "picking up" is eliminated. The convenient height of the rack's upper levels facilitates the moving of the tank and dog house off and on trucks.

Performance Counts Again..

LINK-BELT Roller Chain *Helps Smash 4 Drilling Records!*

Deep Well Breaks Four Drilling Records

By NICHOLAS A. D'ARCY, JR

THE Rocky Mountain Drilling Company, drilling for the Standard Oil Company of California, broke three world's records and one California record in drilling Maxwell No. 1 near Ventura, California. This well, drilled to a total depth of 17,696 ft. was drilled in the fastest time to a comparable depth, is the deepest well ever drilled by a drilling contractor, is the deepest well ever drilled with power equipment, and is the deepest well ever drilled in California.

The well was remarkably free from trouble until the pipe stuck at the final depth, but the most surprising feature of the entire performance was the splendid results obtained with the heavy duty power drilling equipment. The drawworks powered by four 6-cylinder diesel engines hoisted the long strings of drill pipe in about the

P 425.

Standard Oil Company's Maxwell No. 1, near Ventura, California, drilled to a depth of 17,696 feet by Rocky Mountain Drilling Company, using a diesel powered rig. That is the deepest well ever drilled with diesel power.

same time required by conventional steam rigs in the same field. The slush pumps were overloaded to more than double their rated horsepower capacity, but they performed to the entire satisfaction of the contractor.

Hoisting equipment. The entire rig was purchased in 1947 and it was described as a modern power rig capable of drilling 12,500-ft wells. It has lived up to and far exceeded its rated capacity. Maxwell No. 1 was the second well this rig drilled. The drawworks itself is modern in every respect and similar to many power rigs designed for drilling to 12,000 or 13,000 ft, but it was never intended as a depth-breaking piece of equipment. Precision cut teeth, sprockets, oil tight chain guards, friction drum clutches, and dual 40-in. hydromatic brakes with master-carbo-seal and spinning-cat heads are similar to the specifications on countless other similar rigs. It was careful supervision and maintenance that made this a record-breaking

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Maxwell #1 was the second well drilled with this rig.

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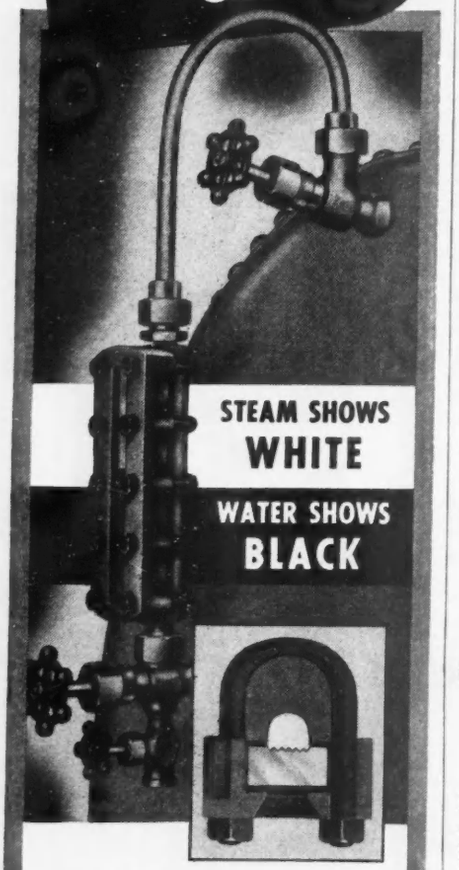

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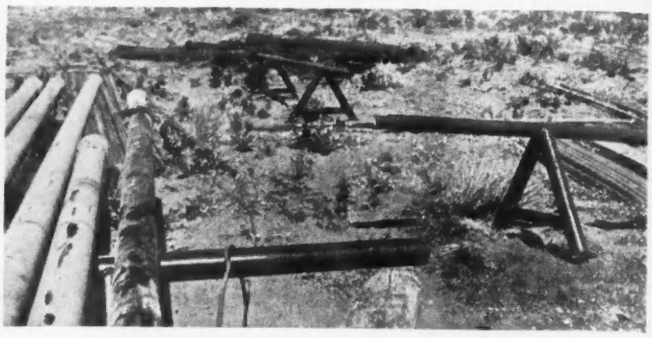
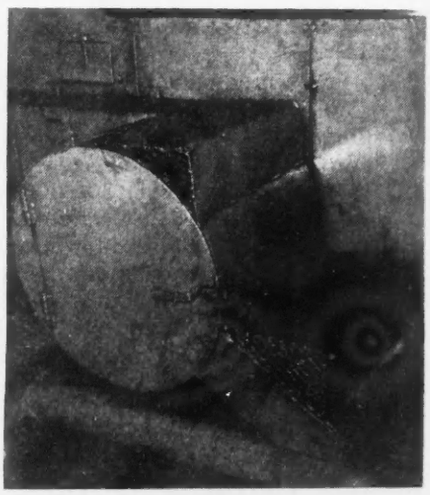
HOW TO—Build Sectionalized Pipe Rack



A small portable pipe rack that is ideally suited for light drilling rigs whose derrick floors are built up close to the ground has the feature of being expandable to suit the particular requirements of any location. Used by a West Texas contractor, the racks illustrated are bulk of salvaged drill pipe and consist of simple A-frame legs welded to horizontal transverse sections of the same material. Each of these horizontal transverse members is provided with a pin on one end and a box on the other, these connectors being carefully constructed so that any section can be fitted into another as racks are made up. Matching holes in the end fittings permit bolts to be dropped through to lock the joints together. The racks are ideal for sandy or irregular terrain where clearing of land would be both undesirable and unnecessary. Square steel plates welded to the bottom of each rack support provide stability when set up in loose or sandy soil.

HOW TO—Make Transmission Clutch Guard



The power transmissions on many power rigs are mounted separately on skids and must be set in place and hooked up at the rig. Such installations have clutches of one type or another protruding from one side, providing a potential hazard.

One contractor, operating a medium-depth drilling rig having a separate power transmission, went to considerable expense to cover the exposed working parts of the unit and to protect the protruding clutch. The main body of the power transmission was covered with sections of light plate steel bolted to an angle-iron framework. This cover extended over all working parts of the transmission, which was mounted on a separate pipe skid. The clutch was protected by a sheet metal cylinder attached to the main cover by tabs and bolts. The end of the cylinder was closed in with a hinged door which was latched closed. Purpose of the door was to provide a means of greasing the clutch bearings and adjusting the clutch from time to time.

The usefulness of this cover was increased by adding steps made of expanded metal in order to provide a safe means for crew members to grease and inspect the transmission and rear of the drawworks. Both sides and treads were made of expanded metal, as shown, while the toe plates were of solid steel plate. The cover adequately protects the clutch and prevents eye injuries as a result of accidentally coming in contact with it while the drawworks are turning. The unit is easy to install and provides a safe stepping point for the crew.

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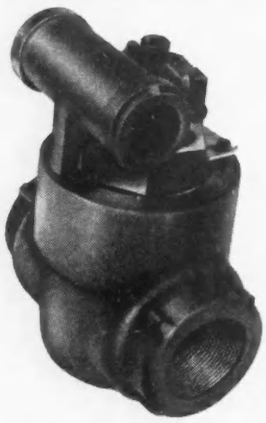

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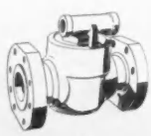

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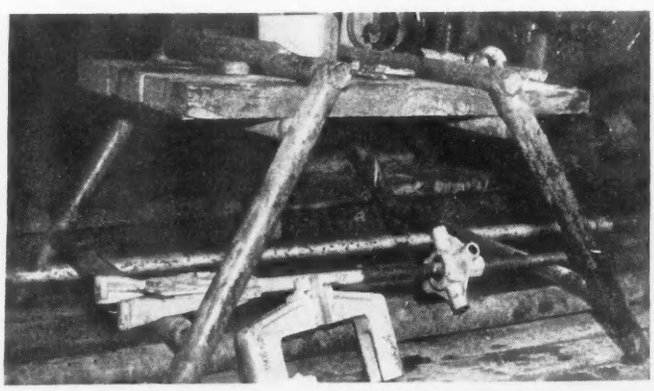
HOW TO—Install Drainage Line in Cellar

In hilly or mountainous areas, work connected with keeping the cellar drained of mud, water and inflammable fluids can be reduced to a minimum by preparing for it somewhat in advance of the actual setting up operations. Before the cellar is poured, a ditch is dug having a slight down grade from the bottom of the cellar out to the edge of the location or waste sump. A 3- or 4-inch pipeline is laid in the ditch, the well end projecting just inside the actual cellar area. Such a provision allows fluids to drain out as they enter, resulting a practically dry cellar at all times.

This practice not only lessens the danger of fires caused by accidental ignition of inflammable fluids, but simplifies work on well head fittings and blow-out preventer equipment. The installation is not very costly inasmuch as all but a few feet of the line may be recovered upon completion of the well.

If desired, the line may be left in the ground in order to provide drainage during the producing life of the well.

HOW TO—Make Sturdy, Collapsible Bench



Small, elevated working benches are almost a necessity around the mud pumps which require replacement of pistons, valves and packing glands. If a working bench is provided, it usually is fixed in position and is not always handy for all the work needed around the pumps.

Illustrated, is a shop-made bench that readily lends itself to such work, whether it be around the mud pumps or on the derrick floor. This particular bench is light enough for one man to drag over relatively short distances, such as from one pump to another. It utilizes the old lever-action principle for construction.

The bench consists of three main parts: the two legs and a top. Each leg is made of two-inch pipe, approximately 3½ feet in length. Two cross braces are welded to the legs at one end, while a third brace is added near the bottom. When a two-inch plank is inserted between the two top cross braces, and both legs are set at angles as indicated, a solid table results. It can be pulled from either end without dismantling the parts. During rig moves, or if it is necessary to move the bench more than 100 feet, it can be easily taken apart, since no bolts or screws are used.

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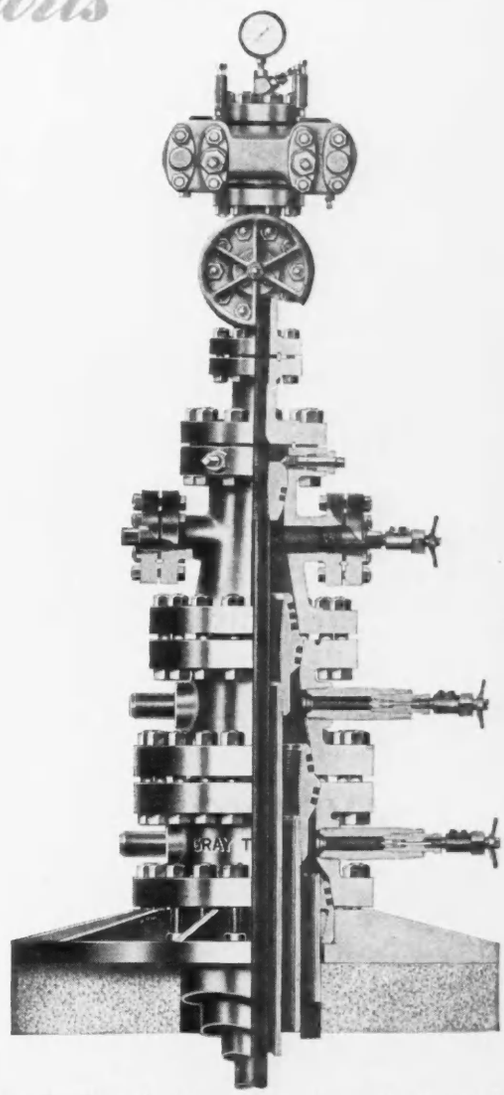

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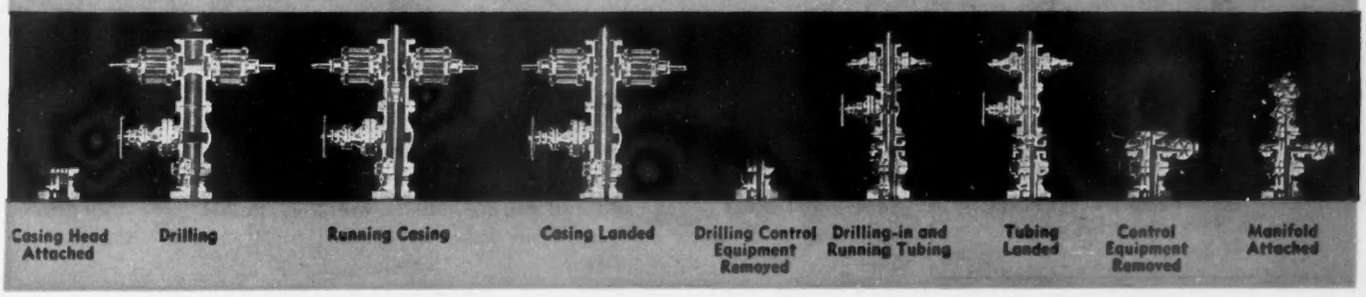

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HOW TO—Add Chemicals at Shale Shaker

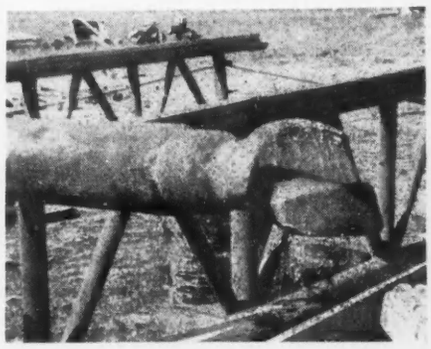
Many innovations for the treatment of drilling fluids may be found on drilling rigs. For the most part, chemicals are usually added at some point between the mud return line at the wellhead and the shale shaker. Somewhat unique and different is the method shown for adding chemicals to the returning mud stream. This rig uses a standard two-chemical treatment, consisting of caustic soda and quebracho, and therefore, only two containers were provided.

The unit is unique in that the chemicals are added at the shale shaker instead of at some point between the shaker and the well; in addition, the chemical containers have been unitized with the shale shaker and mud receiver. This feature has added a convenience and resulted in substantial savings in piping plus the regular saving in time required for setting up and dismantling ordinary treating units.

The rectangular tank is divided into two parts, and is welded as an integral part to the mud receiving tank of the shale shaker. The chemical tanks extend over the back side of the mud receiving tank, and are supported by three angle-iron braces. Each tank is fitted at the bottom with a short nipple and valve to regulate the amount of chemical to be fed into the mud stream. Since the chemicals are mixed with water, each tank compartment is also equipped with a one-half inch water tap, which is a continuation of the water line to the shale shaker. A walk-around of floor plate facilitates the maintenance of the combination shale shaker and chemical treater unit. Tops of the tanks are not so high that the small amounts of dry chemicals used cannot be lifted manually.

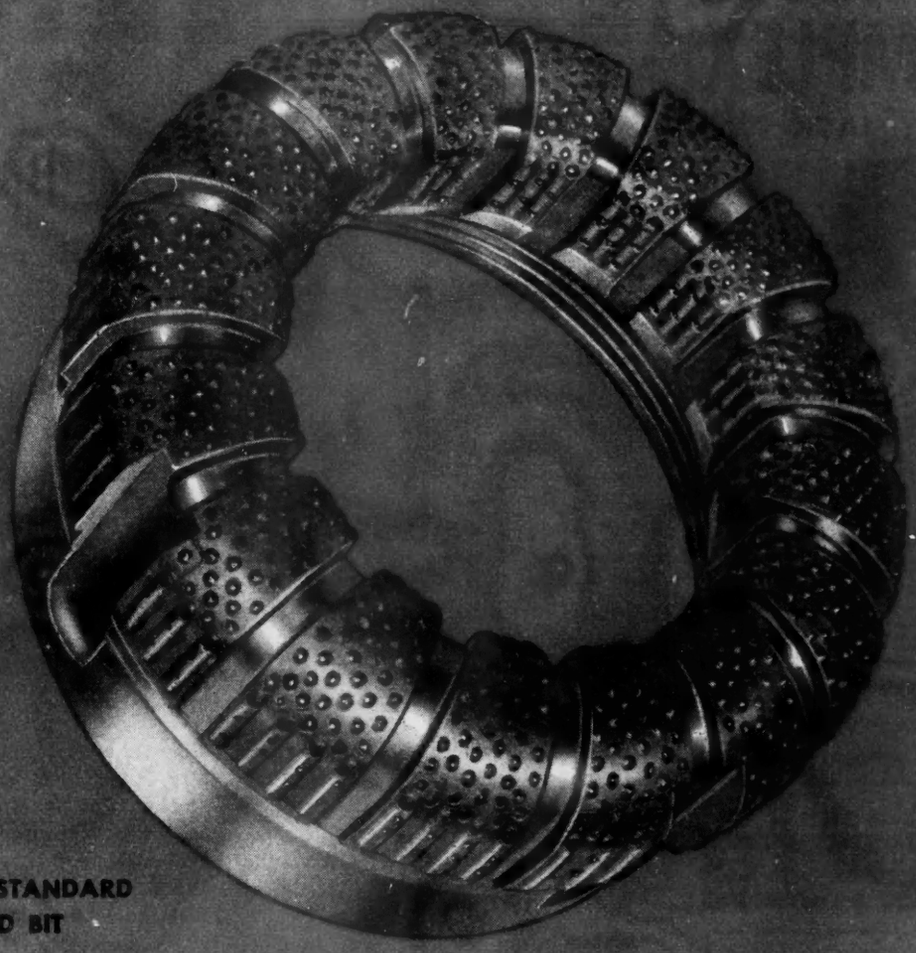
HOW TO—Prefabricate Rat Hole Casing

A drag bit welded to the bottom of the rat hole casing with the female tool joint exposed on the inside bottom makes it possible to leave the kelly in the protective casing when drilling the rat hole. Once drilled, the kelly is unscrewed from the casing, which remains in the ground to form the rat hole casing.



The casing is made from a joint of seven-inch outside diameter pipe with the bottom thread cut off and a 7 x 5-inch swedge welded in place. After the bit is made up on the pin end of the tool joint, it is set up in the swedge and welded, making sure it is in alignment with the casing. The rat hole casing is sufficiently long to permit the kelly to protrude from the opposite end during shipment and during drilling of the rat hole.

When it is necessary to tear down the rig, the kelly is stabbed into the rat hole casing and made up. The combined units are then pulled from the ground and loaded for transfer to the next location.



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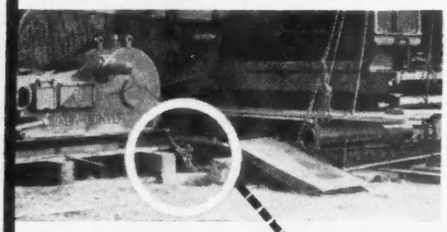

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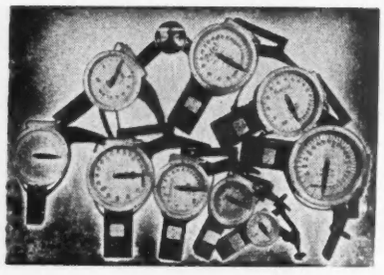

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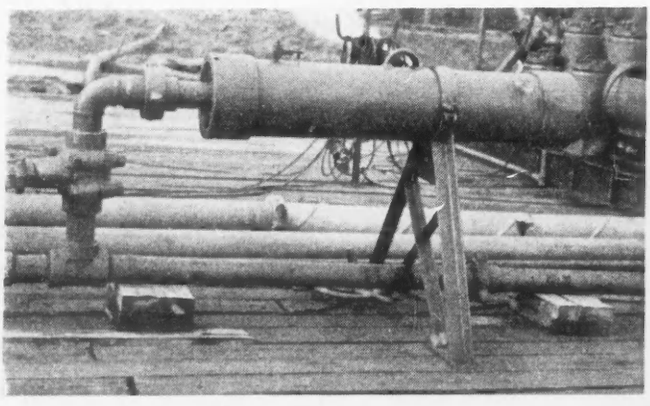
HOW TO—Protect Drill Pipe in Transit

It has been shown in many research projects that drill pipe failures begin with a tiny scratch on the surface of the drill pipe. One manufacturer of tool joints will not allow a load of drill pipe to leave the yard unless the joints are protected from the binding chain with an oak plank. This is accomplished by simply laying a 2x6-inch across the load where the chains cross and looping the hooked eyes over the ends of the plank as well as the ends of the bolsters on the truck and trailer bed. This causes the binders to squeeze the load tightly but does not mar the drill pipe.

Manufacturers lead the way in educating the field men in the proper handling of sucker rods to prevent premature failure, but the simple precaution of placing a plank under the chains on a load of drill pipe has not "caught on" generally with the trucking concerns. When it does, the swamper will find that the load is easier to hold with the plank under the chain, and the driller will have less fishing jobs.

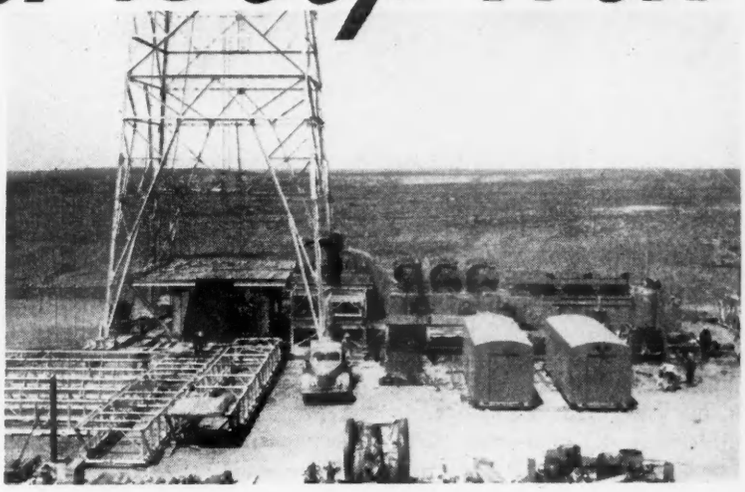
HOW TO—Mount Surge Chamber Horizontally

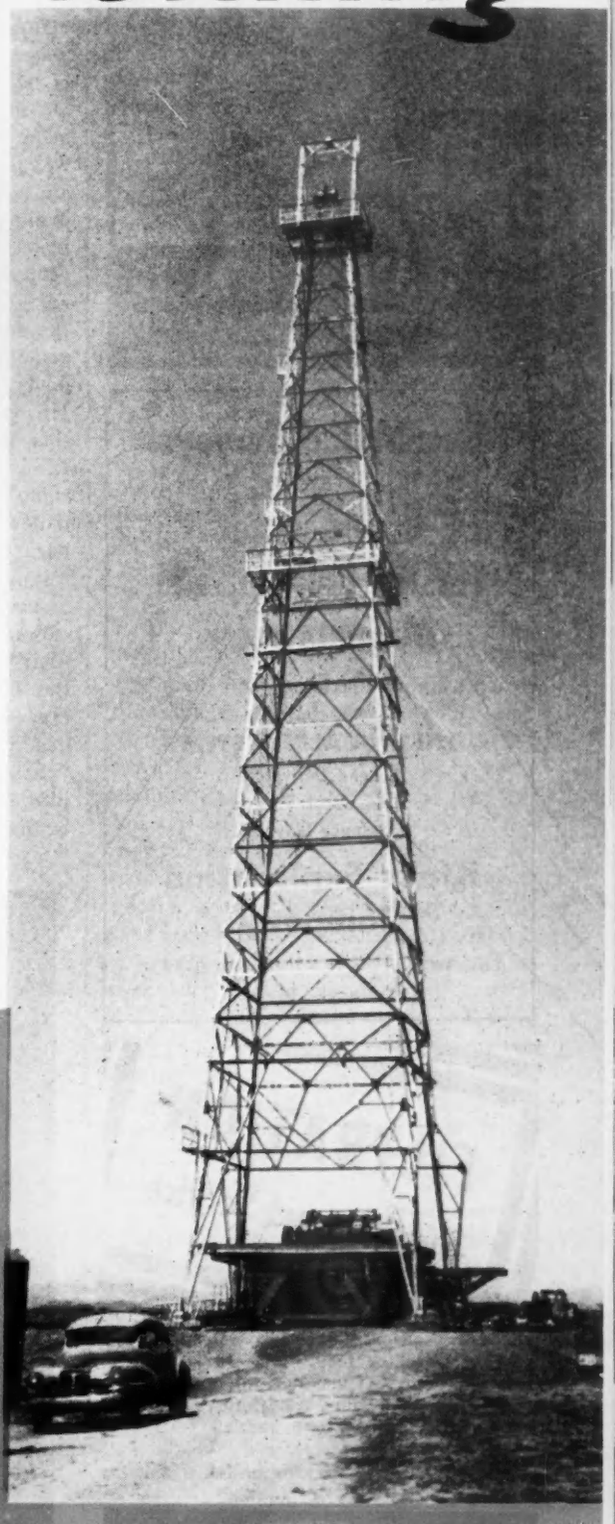


To relieve the mud line of the inverted pendulum effect and consequent stress on fittings, one company mounts the air chamber horizontally above the four-inch pipe carrying mud to the rig, carrying most of the weight of the chamber on a braced A-frame which straddles the line and rests on the timber flooring around the derrick. The frame is not spiked or bolted to the supporting timbers, and thus is able to shift slightly in response to expansion changes in the mud line.

Use of a spherical ground joint in the connection between air chamber and shut-off valve absorbs slight changes in line elevation and possible sinking of the wood flooring without stressing any of the connections. The main mud line itself is braced adjacent to the Tee which carries the chamber valve so as to relieve the absorber unit of the dead load of pipe and fittings.

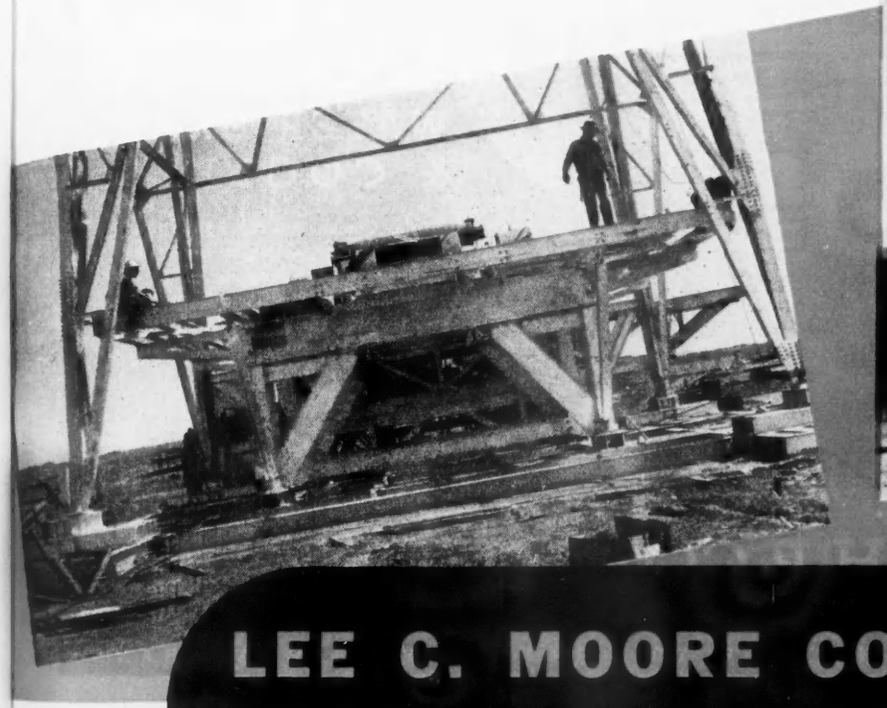
Derricks for Deep Well Drilling





The Draw Works Bench is 6′ high x 14′ 4″ wide x 45′ 4½″ long. Engine foundations are 5′ 6″ high x 42′ 10″ long x 45′ 4½″ wide.

The Lee C. Moore Heavy Series Derricks include the 140′ and the 189′. Intermediate sizes are available. One size can be converted to any other size with a maximum interchange of parts.



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HOW TO—Construct Portable Loading Ramp

When blowout preventers were placed above ground instead of being set in a cellar, the biggest headache which resulted was one of loading and unloading heavy drilling equipment from and onto the elevated derrick floor. In some instances, the distance from the ground to the derrick floor is 17 feet, posing an unusual loading problem. However, the usual method employed in this operation is to criss-cross large 12-by-12-inch timbers until a sloping ramp was made. Wooden planks were nailed to the heavy pieces and the trucks backed on the ramp. However, such ramps were temporary, and must be assembled and disassembled at each location, requiring considerable time, and their temporary nature always imposed the possibility that vibration and use may weaken the structure beyond the desirable safety factor.

Streamlining this piece of equipment into a permanent ramp, yet one that can be hauled from location to location, a drilling contractor, operating in the Gulf Coast area, made the ramp up into two sections, facilitating the moving problem, and providing a flexible unit which can be made to fit the width of any oil field truck. Structural members of this efficient ramp are salvaged 4½-inch drill pipe, welded to form a wedge and vertically braced about every four feet. Each runner is approximately four feet in width and is topped with heavy wood timbers. The timbers are held in place by angle iron which has been welded to the top side of the supporting members. The ramp illustrated was made for one particular rig, but similar ramps can be made to suit most conditions found in the field.

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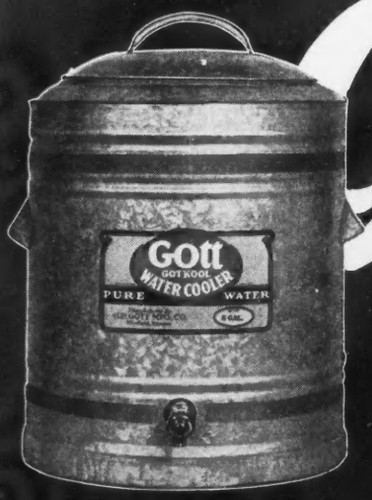

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SHOOTING IN *Water-Flooding*

By S. T. YUSTER,
Chief, Division of Petroleum and Natural Gas Engineering,
The Pennsylvania State College

IN THE production of fluids from, or the injection of fluids into, a reservoir during the process of oil production, the well is the bottleneck of the operation. In order to increase the efficiency of the oil recovery process, it is desirable in many cases to minimize the effect of the bottleneck. This is especially true in the case of secondary recovery operations where there are two sets of bottlenecks, namely, the injection wells and the producing wells. Probably one of the commonest methods of reducing this restriction upon fluid flow is by shooting. Despite the widespread application and importance of shooting in well completions, only a limited amount of quantitative data are available in the literature on the problem.

Shooting Experiments

Phillippi[1] reported on some field shooting experiments carried out on a sandstone outcrop in an attempt to study the extent and character of the fissure system and compare sand tamping with water tamping. No definite conclusions could be drawn from these tests. At the same time, some cooperative research was being carried on by the du Pont explosives research laboratories and the production research laboratories at The Pennsylvania State College on small scale shooting tests using diamond core samples. It was hoped to obtain some quantitative data on the effective or equivalent well radius of the fissure system created which is a true measure of the effectiveness of a shot. It was not possible to confine the fissure system to the 2½-inch cores being used and no conclusions could be drawn from the tests. Barstow and Edgerton[2] in a study of glass fracturing obtained data which is of aid in clarifying the mechanism and character of fissure formation in oil well shooting. They found that the system of fissures consists of vertical cracks radiating out from the point of impact and a series of vertical cracks concentric with the point of impact. Bossler[3] found that the pieces of fractured rock produced by a well shot could be arranged in a pattern similar to that found for glass fractures by Barstow and Edgerton. Evinger and Muskat[4] in a theoretical analysis of the well shooting problem arrive at the probable limits of the relationship of the fracturing radius and shot concentration. These limits are defined, first, by the stresses produced by a static pressure equivalent to the maximum pressure generated by the explosive; and, second, the stresses produced by a pressure pulse with a time rate of application. For a cylindrical cavity, which is the situation in an oil well, they concluded that the fracturing radius would vary as the square root and the square of the charge concentration respectively under the two assumptions given above. Considerable work has been done on the physical size of the well after shooting by the use of calipers of various types. However, such data have very little direct application to well flow, since they measure chiefly the shattering and caving tendencies of the formation.

A STUDY has been made on the effect of shooting in water-flooding. The effect of shooting on spacing, development and operating cost, and gross profit are considered. A corrective shooting formula and chart are developed which give the shell size as a function of permeability ratio in order to cause the flood to penetrate more uniformly. Other factors such as self-correctiveness, multiple shooting, and tamping are also discussed. A brief outline of shooting problems is also given. This paper was presented initially before the Twelfth Annual Conference on Secondary Recovery, School of Mineral Industries, The Pennsylvania State College.

Calculating Effective Radius

In order to approach at least a partial solution to the shooting problem, it is necessary to have some method of calculating the effective radius of a shot well. Such a method applying to water-flooding injection wells within certain limitations has been described.[5] This allows for a determination of the shot responsiveness of a sand under field con-

ditions and when coupled with a knowledge of the effective radius needed for the operation should enable the oil producer to place shooting on a quantitative basis.

Spacing and Shooting

In a large number of water-flooding operations it is necessary to shoot all the wells in order to operate at the highest efficiency and attain a maximum profit. A recent paper on water-flood spacing[6] derives a formula for well spacing for a ten year flood-out program which contains, among other variables, the effective well radius. The formula is as follows:

$$(1)\ W^2(\log W/r_w - 0.420) = \frac{16{,}300kP_b}{\mu R}$$

where W is the water to water well distance in feet for a five-spot; r_w is the effective well radius in feet; k is the effective permeability of the sand to the flood in millidarcys; P_b is the effective flooding pressure in pounds per square inch (for a pumping operation P_b is the bottom hole pressure in the injection well, while for a flowing operation P_b is the applied surface pressure at the injection well), μ is the viscosity of the injected water at formation condition in centipoise (this may be considered equal to one under most conditions), and R is the recoverable oil in barrels per acre foot. This relationship is plotted in Figure 1 with W as a function of the ratio kP_b/R. There are three iso-effective radius lines. The chart can be used to compare the spacing of shot and unshot wells. In order to compare spacing using unshot and heavily shot wells having a 25-foot effective radius, the following conditions approximating the Bradford area will be applied:

Effective permeability, k	1 md
Effective flooding pressure, P_b	2000 psi
Recoverable oil per acre foot, R	200 bbls.

The kP_b/R ratio would be ten and the spacing for unshot and heavily shot wells is 250 and 430 feet, respectively. If the above property were developed for flowing and the maximum safe sand face pressure were 2000 psi, the effective flooding pressure would be 1140 psi. Applying this new condition, the kP_b/R ratio would be 5.7 and the spacing would be 200 and 350 feet, respectively, for the unshot and heavily shot wells. Using an equation for calculating the gross profit on a water flood, given in the paper just mentioned, it will be possible to compare the above operations. The equation is:

$$(2)\ G = Rh(0.875M - 0.18 - 0.0000668P - 0.00042L - \frac{87.120C}{W^2})$$

where G is the gross profit per acre; Rh is the recovery in barrels per acre, M is the price of crude per barrel; P is the well-head injection pressure; L is the depth of the well in feet; and C is the average cost of a well in a five-spot.

Assuming 25 feet of sand, the recovery per acre would be 5000 barrels. Let the price of crude be $5 per barrel, P equal 1140 psi, L equal 2000 feet, and C equal $5200 for a shot well in pumping and $4400 in flowing. Allowing $360 for shooting and cleaning out costs an unshot well would cost $4840 and $4040, respectively. Table 1 gives a summary of the operating conditions of the examples considered above and the resulting gross profit:

It can be seen that the gross profit is considerably greater when using the shot wells. If the price of crude were $2.50 per barrel such as in the Mid-Continent, the gross profit on all of the above developments would be decreased by $12,500, resulting in a loss in the unshot operations. Higher effective permeabilities would improve the situation.

Possible Oil Losses Due to Shooting

The discussion so far has assumed that spacing and shooting have no effect upon the ultimate oil recovery. Both affect pressure gradients with the latter not only increasing it but tending to make it more uniform throughout the pattern. The effect of pressure gradients upon recovery is not understood too well. The laboratory and field evidence is controversial on this point and therefore recovery will be considered as independent of pressure gradients in this discussion.

There is one other factor related to shooting which may have an effect upon recoveries. It was pointed out earlier that studies on the fissure pattern resulting from shooting showed one system of fissures radiating out from the well and another system concentric with it. These fissure systems in order to give effective well radii as high as 25 feet and even higher must extend beyond this distance from the well. It is conceivable that flood waters will bypass recoverable oil in the fissured areas and reduce the total recovery. What the extent of such possible losses may be is not known but it could be considerable. It has been contended that the losses might be small, but the explanation given assumes only a radiating fissure system with no fissures perpendicular to them. These latter fissures would aggravate any bypassing tendencies. Areas which have been bypassed may have the flood waters move some of the recoverable oil from them but it is doubtful if very much of such oil would reach the producing well.

It would be of interest to calculate the

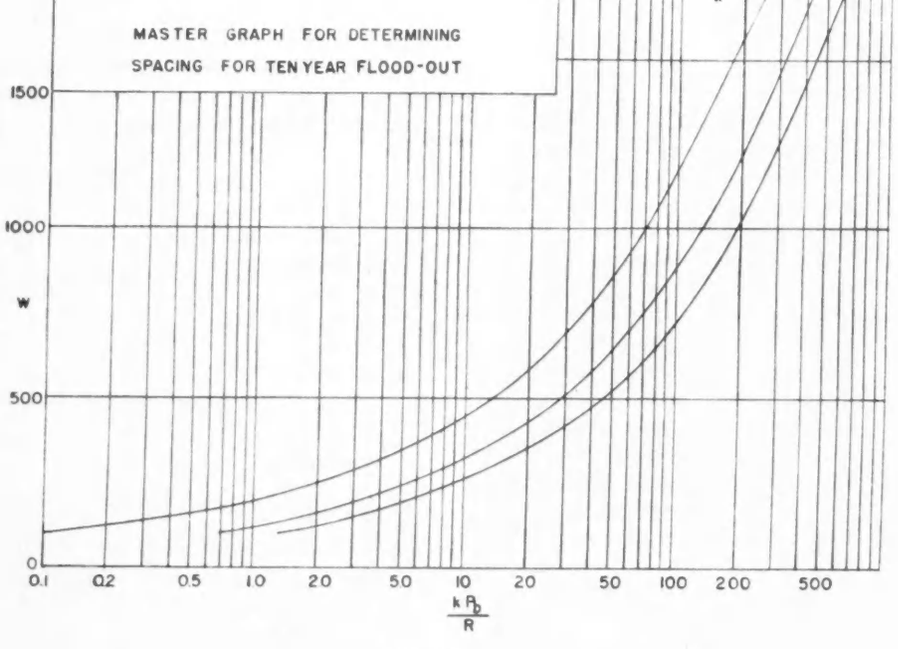
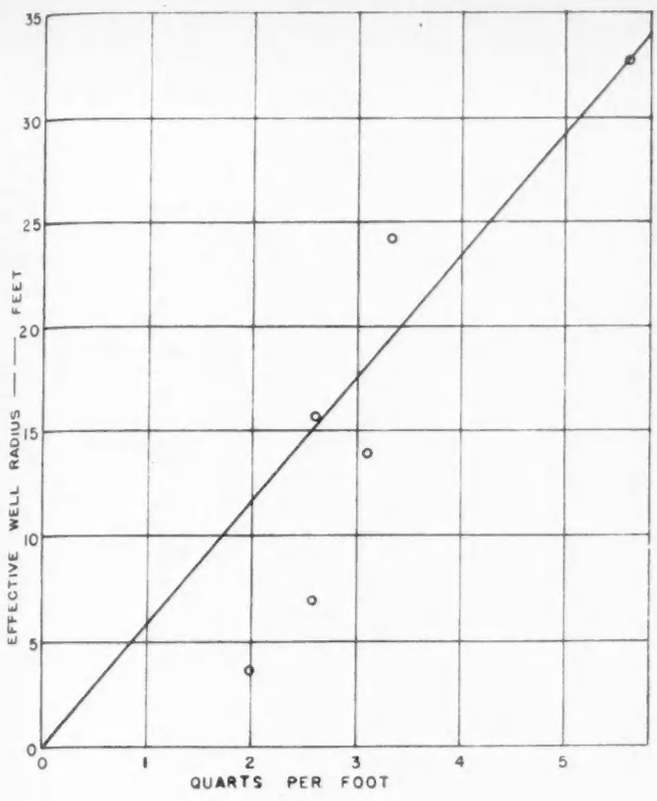


FIGURE 1.

TABLE 1

Effect of Shooting on Spacing and Gross Profit for a Bradford Five-Spot Development

Type of Development	10-Year Flood-Out Spacing		Gross Profit Per Acre	
	Shot	Unshot	Shot	Unshot
Pumping	430'	250'	$13,950	$ 9,650
Flowing	350'	200'	17,470	11,800



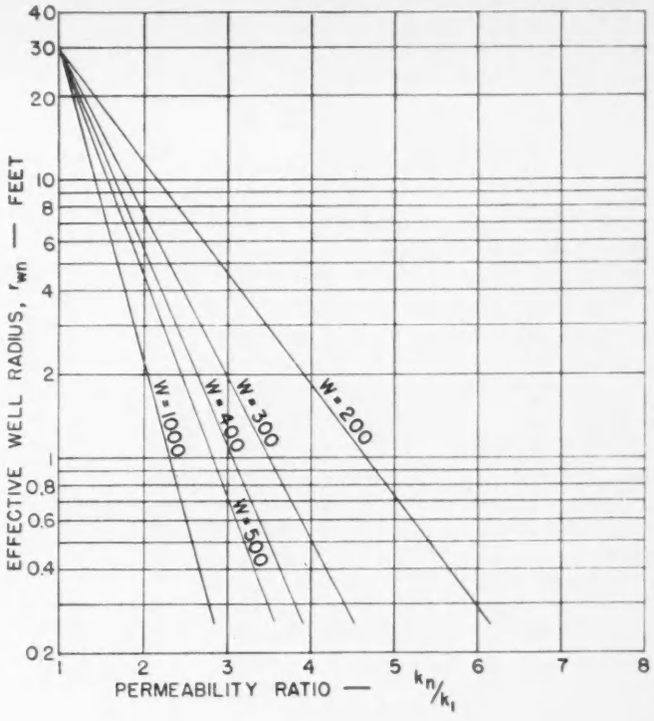


FIGURE 2 (Upper Left). Shot responsiveness of a Bradford sand.

FIGURE 3 (Upper Right). Effective well radius vs. permeability ratio and spacing.

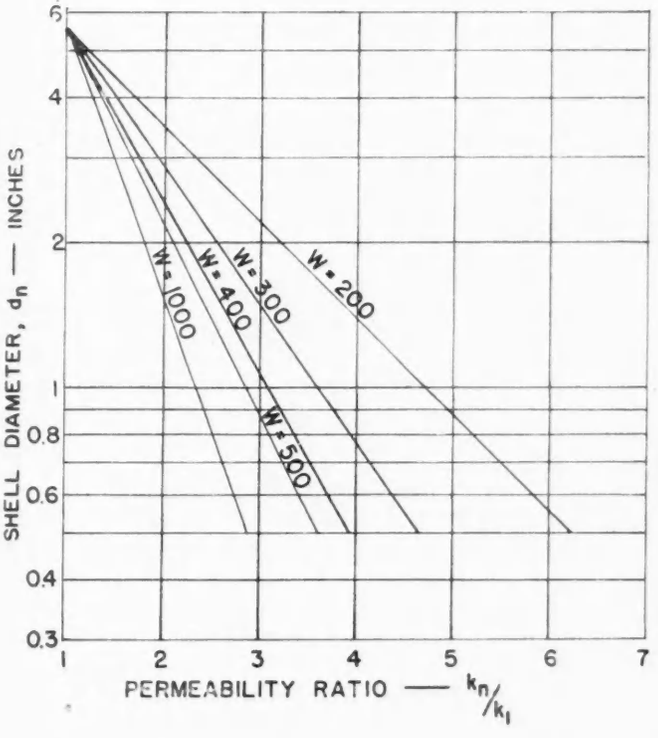


FIGURE 4 (Left). Shell diameter vs. permeability ratio and spacing.

quantity of oil which would be lost and therefore the reduction in gross profit if it is assumed that no oil would be recovered in the area represented by the effective radius. To accomplish this, equation (2) for the gross profit would be modified to

$$(3)\quad G = Rh\left(1 - \frac{2\pi r_w^2}{W^2}(0.875M - 0.18 - 0.0000668P - 0.00042L)\right.$$

$$\left. - \frac{87.120C}{W^2}\right.$$

The additional parenthetical expression represents the fraction of the total area which will be flooded. With the wells shot to a 25-foot effective radius and assuming a loss of recoverable oil, the gross profits given in Table 1 would be reduced to values of $13,600 and $16,870 for the pumping and flowing operations, respectively. In the pumping operation about 2.1 percent of the oil was lost, while in flowing the loss was approximately 3.2 percent. Despite the loss in oil, the development which was shot gave the greatest profit.

It would appear from the results of this analysis that it is advisable to shoot the wells in a development as hard as possible and adjust the spacing to com-

plete the flood in a desired interval of time.

Corrective Shooting

In addition to the beneficial effects of shooting a uniform permeability sand noted above, a shot may be so tailored as to at least partially correct a heterogeneous permeability profile and cause the different strata to produce at a more uniform rate. This corrective or selective shooting is accomplished by placing the highest shot concentration opposite the strata having the lowest permeability, reducing the concentration as the permeability of the strata increase, and if the permeability of a stratum is sufficiently high no shot is used opposite it. While this shooting technique has been in practice for some time there are no published methods available for computing a corrective shot.

There are several conditions which must be known or satisfied if this method is to be applied successfully. They are as follows:

1. The vertical movement of fluids between strata must be at a minimum, which means a low vertical permeability or a separation of the strata by impermeable barriers.
2. There must be a minimum effect on neighboring strata of the explosive charge opposite a given stratum.
3. The shot responsiveness of the formation should be known.
4. The effective radius distribution of the strata for the best collective flood advance must be obtained.

For the best corrective shot, the different strata should act independently of one another which requires the presence of very low vertical permeability or barriers such as shale breaks. The cross migration of fluid nullifies the effect of the corrective shot by bypassing areas containing recoverable oil.

If a shot produces effective radii of the order of 25 feet in a horizontal direction, it might be expected that a comparable fissure system would extend in a vertical direction. Ryder[7] has pointed out that packers have been successfully placed for many years within two feet of the top of a 5½-inch shell in the Bradford area. The explanation for this behavior may be in a phenomenon known in seismograph work. Waves generated by a shot may travel along strata discontinuities and are then detected at the surface by the head waves produced. It may be that the bedding plane in the sand and shale partings cause the explosive wave to be preferentially conducted in a horizontal direction and therefore give a minimum effect vertically.

Shot Responsiveness

A method for obtaining the effective well radius or shot responsiveness of the formation under certain conditions has been described in a paper already mentioned.[5] The cumulative volume of water injected and the corresponding rate of injection into a fairly uniform permeability sand are required in addition to the regular core data. This information should be substituted in the following equation:

$$4)\ \log V = \frac{0.00617kh(P_i - P_f)}{\mu}\ \frac{1}{Q} + \log 0.559\, fh(1 - w - S_r)r_w^2$$

where V is the cumulative volume of water injected in barrels, k is the effective permeability of the sand to the flood in mds.; h is the sand thickness in feet; P_i and P_f are the sand face injection pressure and formation pressures respectively in pounds per square inch; Q is the injection rate in barrels per day; f is the fractional porosity of the sand; w is the fractional connate water saturation; S_r is the fractional residual oil saturation.

According to this equation plotting the log of the cumulative volume versus the corresponding reciprocal of the daily rate should give a fairly straight line with a uniform sand up to the limit of radial encroachment. The slope of the line allows for a computation of the field effective permeability and the constant term can be used to obtain the effective well radius. If the injection pressure has varied but its value is known, $\Delta P/Q$ should be plotted versus log V. This method has been applied under the conditions indicated and good results obtained.

No simple quantitative test has been developed as yet for determining the shot responsiveness of a formation. A simple qualitative laboratory test has been used which involves dropping a weight from gradually increasing heights on a wafer of core about one-half inch thick. If the sand fractures clearly with very little formation of fines, it should be fairly responsive to shooting. If a considerable quantity of fines is produced, a shot will probably give a maximum of shattering of the formation with only a relatively few fissures produced.

One quantitative test for shot responsiveness requires that several cored injection wells in a uniform sand area be shot uniformly with different concentrations of explosive. The water input data are then analyzed using the method already described in order to obtain the effective well radius. The radii are then correlated with the shot concentration. If the sand is non-uniform in a vertical direction it will not be possible to plot the log V vs. 1/Q data to give a straight line. Under such circumstances a trial and error graphical method may be used. A nomograph for predicting water intakes[8] is applied to the brackets of permeabilities existing in the sand assuming several relative permeabilities. By shifting the log V scale upward or downward, it is possible to change the effective well radius. Choosing several reasonable values for the relative permeability and effective radius a summation of V's and Q's for the strata as a function of time is obtained. When the actual input data are matched, the correct r_w and k_r have been obtained.

In order to determine the shot responsiveness of a sand some data were analyzed from the Kanesholm lease (Kane pool, McKean County, Penn.) of the Kendall Refining Company. The wells were not as closely grouped as would be desired, thereby raising the question regarding the sand uniformity. However, the data are probably as good as can be expected from the field. The shot concentration and well radii are given in Table 2.

TABLE 2

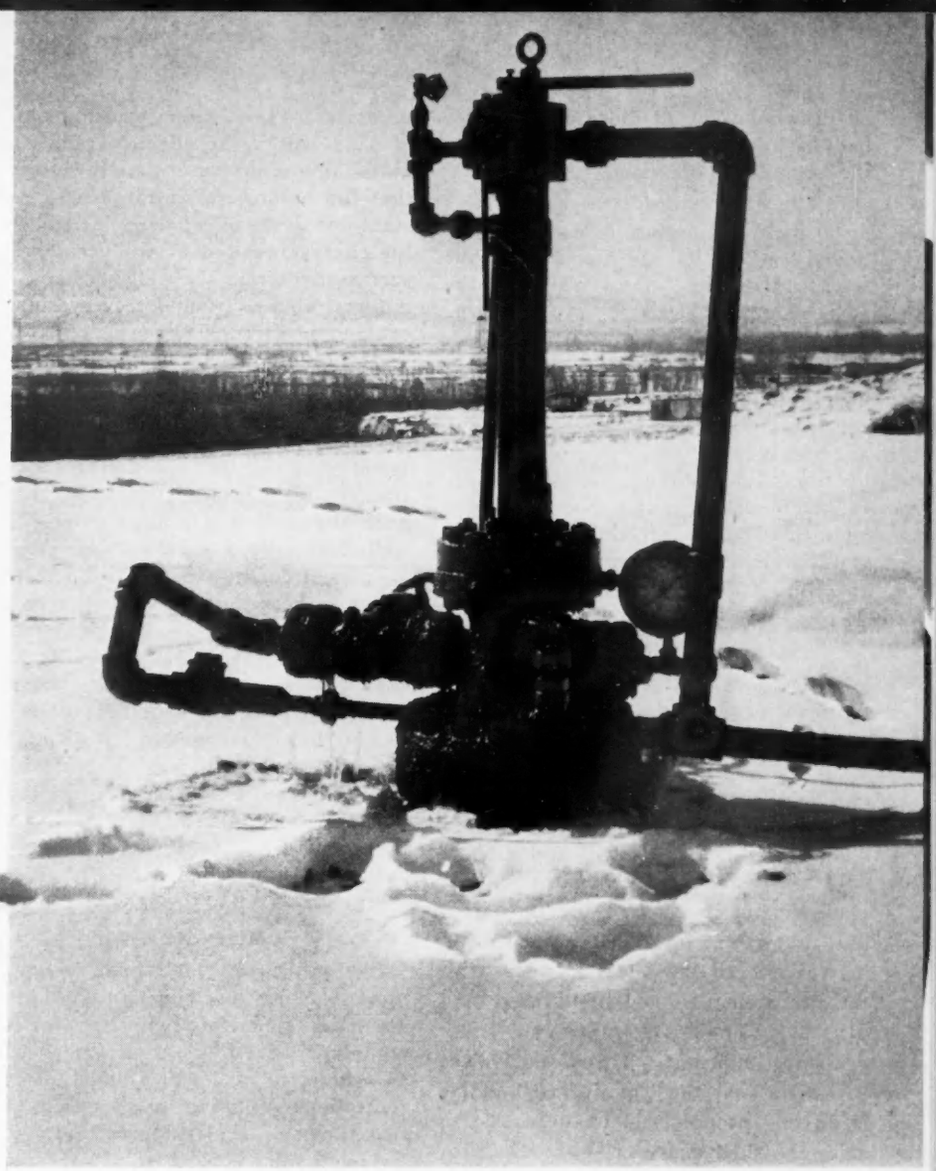
Shot Responsiveness of Bradford Sand

Shot Concentration Quarts per Foot	Effective Well Radius Feet
2.0	3.5
2.6	6.9
2.6	16.1
3.1	14.0
3.3	24.5
5.6	33.0

Statistical Study

Since a large number of variables enter into the shot responsiveness of a formation and since it is almost impossible to expect such variables to remain constant over a wide area in a sand, the study of shot responsiveness should preferably be a statistical one. However, since such field experimentation is very costly, and may lead to unfavorable production, practically none of such work has been done. While a larger number of tests would have been desirable for this analysis, it is fortunate that as wide a range of shot concentrations is included.

The data from Table 2 are plotted in Figure 2. It can be seen that the data do not line up too well. The line which has been drawn was placed very arbitrarily and the only thing certain about it is that it must start close to the origin. The data were plotted on log-log graph paper in an attempt to obtain the coefficient and exponent of the shot concentration so as to correlate it with r_w. Lines having slopes from 1 to 4 could



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be drawn but in all cases some points had to be disregarded. This points to the need for more data.

In the theoretical analysis of this problem by Evinger and Muskat[4] mentioned earlier, it was found that the fracturing radius might vary as the square root to the square of the charge concentration.

In the section on the calculation of demolition charges in the Reserve Officers Training Corps Engineer's Manual, a series of empirical equations based upon considerable experience is given for the breeching radius. For distributed charges (charges placed in a continuous row) which is the condition in well shooting, the following equation modified to apply to this discussion is given:

$$(5)\quad r = \sqrt{\frac{N}{2.3KC}}$$

where N is a quantity representing the charge concentration, K is an approximate constant dependent upon the type of material being blasted, and C is a constant which is dependent upon the placement of the charge and the tamping (usually one for a well-tamped shot). The above relationship is identical with the variation predicted by Evinger and Muskat assuming a maximum static pressure application. This is equivalent to saying that the effective well radius is directly proportional to the shell size since the shell diameter squared is proportional to the quarts per foot.

Upon first analysis this may appear logical when considering the energy necessary to form fissures in the volume of sand out to the effective radius. As a first approximation it may be assumed that the fissure concentration is a constant out to the effective radius and that the energy required to produce this fissure system from the well bore and out is therefore a constant for every volume of sand involved. This means that the volume of the explosive used is directly proportional to the volume of sand shot or the effective well radius should vary directly as the shell radius. Since it is to be expected that the fissure concentration in the sand would be greatest near the well and decrease from the well bore out, a somewhat decreasing amount of energy would also be utilized per unit volume of sand. Such a condition may cause the effective well radius to vary as some power other than the first power of the shell size or the square root of the shot concentration. This is borne out in Table 3 giving the variation of K with r of Equation (5). The trend in the value of K indicates that a slightly higher root than is given in Equation (5) is needed to relate r_w as a simple function of the charge concentration.

Mines Report

In the Bureau of Mines report on mine blasting[5] an equation is derived assuming spherical symmetry for the amplitude of vibration of a formation as a function of distance and shot concentration. Applying the same line of reasoning to cylindrical symmetry (which applies in the case of well shooting) gives the following development: The energy of vibration of a rock particle at some given distance from the shot should be directly proportional to the shot concentration or

$$(6)\quad E = aG$$

where E is the energy of vibration, G is the shot concentration in quarts of nitroglycerine per foot and "a" is a proportionality constant. If it is assumed that the vibratory energy is propagated in a homogeneous medium from a line source, then the total energy passing through any two concentric cylinders is the same. This supposition assumes that the act of energy transmission does not change the ability of the formation to transmit. Since the area of a given length of cylinder varies directly as the radius, the energy passing through a unit area of the cylinder is inversely proportional to the radius. For a constant energy source

$$(7)\quad E = b/r$$

where r is the distance out from the shot and b is a proportionality constant. Combining the proportionalities given in equations (6) and (7) gives

$$(8)\quad E = c\,\frac{r}{G}$$

If the vibration is simple harmonic with constant frequency, then the energy at any point in the sand is directly proportional to the square of the amplitude. In these Bureau of Mines studies this last condition was found to be reasonable in some oscillograph records. In equation form this is

$$(9)\quad E = dA^2$$

where A is the amplitude of vibration of the rock and d is the proportionality constant. Combining equations (8) and (9) and solving for r gives

$$(10)\quad r = e\,\frac{G}{A^2}$$

If there is some minimum amplitude which if exceeded will result in a fracture, then the above equation will give the limiting fracturing radius in terms of the shot concentration, a threshold amplitude, and a proportionality constant. In this case the fracturing radius is directly proportional to the shot concentration.

The preceding theoretical considerations all interpret a shot in terms of a

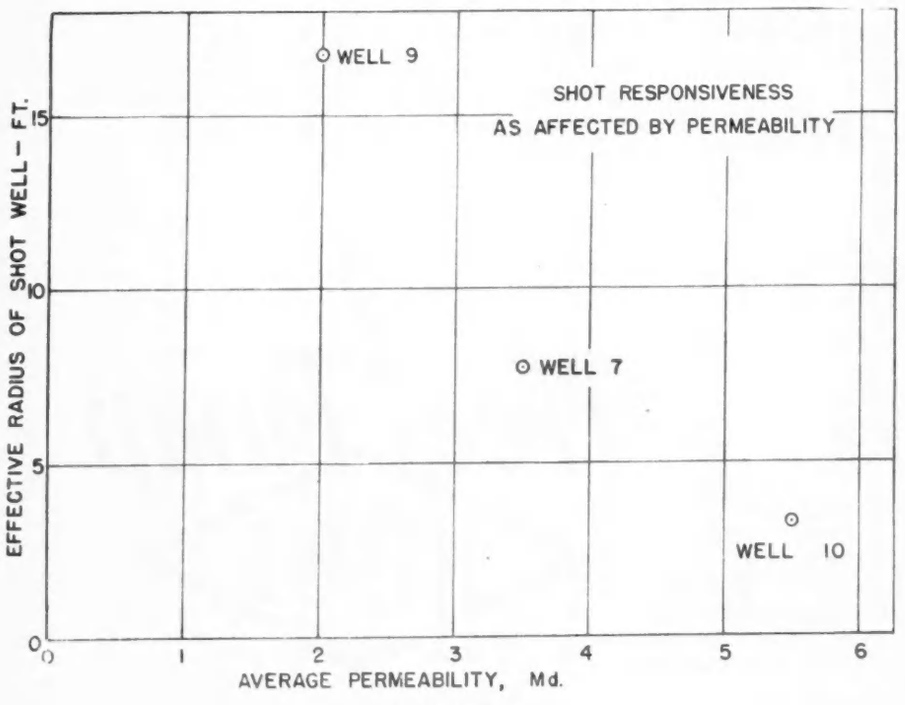

FIGURE 5.

TABLE 3
Variation of K with r for a Good Masonry, Concrete or Rock

r	K
Under 3 feet	0.63
3—5 feet	0.50
5—7 feet	0.44
Over 7 feet	0.38

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maximum fracturing radius. While this is of importance in well shooting it does not give the effective well radius directly. The fissure concentration, pattern, size, and distribution would determine this, and it is difficult to conceive of a theoretical analysis which would give all of these factors and thereby arrive at the effective radius. However, these theoretical studies may aid in establishing a trend in experimental data.

The data of Figure 2 show a very rough correlation between the first power of the shot concentration and the effective well radius and it is this relationship which will be assumed during the rest of this discussion. If G is the quarts of nitroglycerin per foot, the equation of the line in Figure 2 is

$$(11)\quad r_w = 5.9G$$

The proportionality constant in the above equation could be designated as the shot responsiveness of the formation. If the relationship between the variables had not been linear as above both a coefficient and exponent of G would have been necessary to define the shot responsiveness.

Effective Radius and Permeability

The remaining information necessary to calculate a corrective shot is the effective radius distribution as a function of the permeability. If it is assumed that the equation for the steadied water input rate in the five-spot defines the average water rate in a stratum, it is possible to calculate a corrective shooting equation. The five-spot flow formula is:

$$(12)\quad Q_s = \frac{0.00154khP_b}{\mu(\log \frac{W}{r_w} - 0.420)} = \frac{0.00154khP_b}{\mu \log \frac{0.38W}{r_w}}$$

If two strata of different permeability are to flood at the same rate by an adjustment of the respective effective well radii, two equations like the above, one for each stratum, are equated at the same input rate per foot. In simplified form this is

$$(13)\quad \frac{k_1}{\log \frac{0.38W}{r_{w1}}} = \frac{k_n}{\log \frac{0.38W}{r_{wn}}}$$

Eliminating the logarithms and solving for r_{wn} gives

$$(14)\quad r_{wn} = 0.38W\left(\frac{r_{w1}}{0.38W}\right)^{k_n/k_1}$$

which gives the effective radius of the nth permeability bracket in terms of the spacing, the effective radius of bracket 1 and the permeability ratio of the two brackets.

Another approach to a corrective shooting equation involves the use of the equation for radial encroachment as a function of time.[10] This is

$$(15)\quad R^2\left(\log \frac{R^2}{r_w^2} - 0.435\right) + 0.435\, r_w^2 = \frac{0.011kP_bt}{f(1-S_r-w)}$$

which gives R versus t in terms of the variables involved. In order to have two permeability brackets water out at the same time r_w would be varied, keeping all variables constant except k. By dropping the r_w term outside the parenthesis since it becomes negligible at the usual values of R, and combining two such equations as was done previously

$$(16)\quad \log \frac{R^2}{\frac{2.72r_{wn}^2}{k_1}} = \log \frac{R^2}{\frac{2.72r_{w1}^2}{k_n}}$$

Assuming that the equation for radial encroachment will hold approximately to a point half way between the actual limit of radial encroachment and the position of the producing well, then the limiting value of R would be

$$(17)\quad R_L = \frac{1}{2}\left(\frac{w}{2} + \frac{w}{\sqrt{2}}\right) = 0.6W$$

Substituting this value of R in equation (16) and simplifying gives

$$(18)\quad \log \frac{w}{\frac{2.75r_{w1}}{k_1}} = \log \frac{w}{\frac{2.75rw_n}{k_n}}$$

Eliminating the logarithms and rearranging gives

$$(19)\quad r_{wn} = 0.364W\left(\frac{r_{w1}}{0.364W}\right)^{k_n/k_1}$$

This equation is almost the same as equation (14) but probably predicts the actual behavior a bit more closely. It will be used as a basis for subsequent calculations. It would be of interest to plot equation (19) in order to determine the effective well radius as a function of the permeability ratio. For this purpose, it would be convenient to put the equation in logarithmic form.

$$(20)\quad \log r_{wn} = \frac{k_n}{k_1}\log \frac{r_{w1}}{0.364W} + \log 0.364W$$

Plotting r_{wn} versus k_n/k_1, should give a straight line on semi-log paper. If r_{w1} is considered the effective radius opposite the lowest permeability bracket then it should have the maximum value or that obtained with the largest size shell which can be placed in the well. Assuming a 6½-inch unshot hole, the maximum size shell which can be run safely is 5½ inches. This is equivalent to a shot concentration of 4.94 quarts per foot. According to Figure 2, this size shot will give an effective radius of 29 feet. Substituting this for r_{w1} in the equation gives:

$$(21)\quad \log r_{wn} = \frac{k_n}{k_1}\log \frac{79.6}{W} + \log 0.364W$$

Figure 3 is a plot of the above equation with "W" as a cross variable. Choosing the 300-foot spacing line as an example, it can be seen that the maximum permeability ratio which can be corrected for in the particular sand from which the field data were obtained is 4½. Any ratio above this can be given only a partial correction. The greater the spacing and the less the shot responsiveness of the sand, the less the extent of correctiveness possible.

Using Shell Size

In order to convert equation (20) to a more usable form shell size will be substituted for effective well radius. In order to do this it will be necessary to relate the shot concentration with shell size. This is

$$(22)\quad G = .1633d^2$$

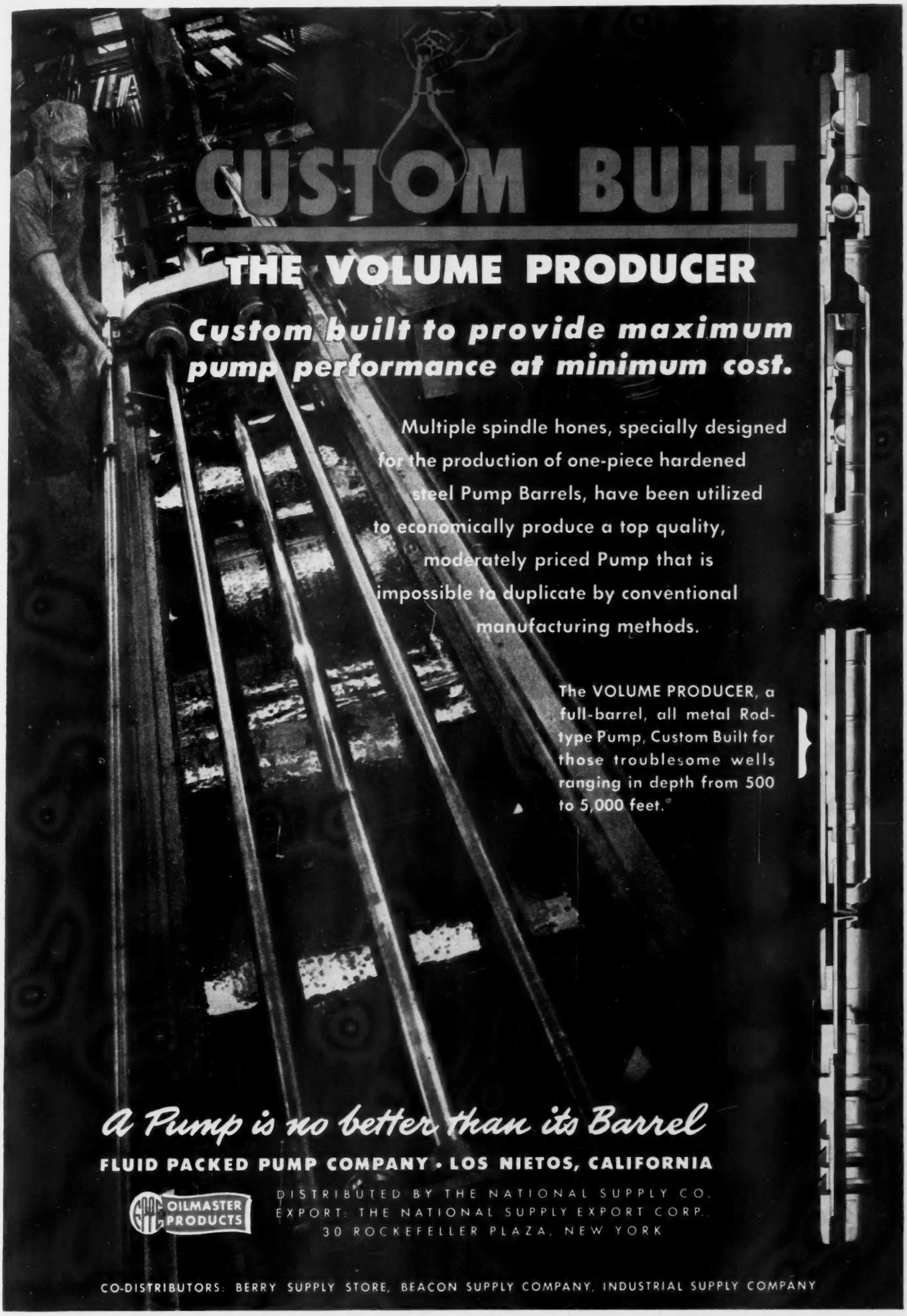
where d is the shell diameter in inches. If the proportionality constant in equation (11) is set equal to "J" and assuming that the linearity between r_w and G is general then

$$(23)\quad r_w = 0.1633Jd^2$$

Substituting for r_w in (20) gives

$$(24)\quad \log d_n = 0.5\frac{k_n}{k_1}\log \frac{Jd_1^2}{2.23W} + 0.5\log \frac{2.23W}{J}$$

which gives the shell diameter as a function of the permeability ratio. The term d_1 is now the maximum shell diameter which may be placed in the well. Assuming this to be 5½ inches and letting J equal 5.9 Figure 4 shows the relationship between shell size and permeability with spacing as a cross variable. The lines were stopped at a shell diameter of one-half inch since this value, substituted in equation (23), gives an r_w of about 0.25 which is the radius of an unshot hole. This apparent anomaly of a shot giving the radius of an unshot hole is due to the fact that equation (11) does not hold for values of r_w of the order of the unshot radius. In fact, a one-inch shell may represent the lower limit of practicability. Similar graphs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should be drawn for the "J" factor of a given area.

In applying this corrective shooting chart the maximum k_n/k_1 ratio should be kept in mind since this represents the limit of correctiveness. As an example, the 300 foot spacing line indicates that permeability ratios up to about 4½ may be corrected. In almost all instances the maximum permeability ratio between brackets containing economically recoverable oil is greater than this. This means that some strata will be corrected only partially by a shot. The span of corrected brackets can be chosen technically in any part of the permeability distribution. For economic reasons it would be well to place it somewhat near the center or around a weighted average permeability.

In a recent paper on water-flood spacing[6] an equation was given for obtaining such an average permeability. It is

$$(25)\quad \bar{k} = \frac{\Sigma khR}{\Sigma hR}$$

where R is the recovery per acre foot. Dividing this value of permeability by one-half of the maximum permeability ratio which can be corrected will give the k_1 needed for calculating corrective shots. Permeabilities below k_1 will be shot with the maximum size shell and permeabilities above the maximums involved in the correction will remain unshot. In equation form this would be

$$(26)\quad k_1 = \frac{2\bar{k}}{(k_n/k_1)_{max.}}$$

An example will serve to illustrate the method. A sand is to be drilled up on a 300-foot spacing. Corrective shots are to be designed for the wells. The sand is broken up into convenient permeability brackets and the required data substituted in equation (25) to obtain an average k which will be assumed to be 5 md in this example. According to Figure 4, the maximum permeability ratio which may be corrected in a 300-foot spacing is 4.6. Substituting these values in equation (26) gives k_1 equal to 2.18 md. The bracket nearest this value is chosen as bracket 1 and the permeability ratios calculated on all the brackets with 1 as a standard. The corrective shooting chart is used for all permeability ratios from 1 to 4.6. Brackets having permeability ratios below 1 are shot with the maximum size shell. Brackets having permeability ratios above 4.6 are left unshot.

Extent of Correctiveness of Shots

In all of the considerations so far, it has been assumed that the respective strata respond only to the shells opposite them and that there is very little overlap. Some overlap is unavoidable,

TABLE 4
Effect of Multiple Shot on Oriskany Sand Gas Wells

Well No.	FIRST SHOT			SECOND SHOT		
	Total Qts.	Qts./ Ft.	r_w	Total Qts.	Qts./ Ft.	r_w
3	12	2	1.9′	12	2	3.2′
7	15	1.5	7.7	20	2.5	27.8
9	10	2	16.7	10	2	64.7

but a considerable amount of it would tend to nullify the correctiveness. It was pointed out earlier that packers have been set successfully within two feet of the top of a 5½-inch shell and that this may be due to horizontal planes of discontinuity in the formation. However, a proof of correctiveness requires an input profile of a well and the interpretation of the data to effective well radius distribution. McCormick and Pfister[11] reported on some water input profile measurements and found a definite correctiveness. It was not possible to calculate the effective radii so the results were only semi-quantitative. More of such work is needed under conditions in which the different variables are known in order to evaluate the extent of correctiveness of a shot.

Self Correctiveness of Sand

There is very little question but that the mineral makeup and texture of the sand is one of the chief controlling factors in the response of a formation to a shot. Since these in turn affect permeability it may be that the different permeability strata of a given sand may respond differently to shooting. Such a study was made on some Oriskany sand gas wells.[12] Unfortunately, only three wells had the required data and the spread of permeabilities is very limited. The results are given in Figure 5. A trend of greater responsiveness for lower permeabilities is shown. In view of the very small number of wells involved, the trend may be only a coincidence and actually non-existent. Again it may be true for one sand and not another. Considerably more work is needed to clarify this point.

Multiple Shooting

Since the quantity of the explosive or the size of the shells which can be placed in an unshot well is limited, thought has been given to various methods which can be used to increase the shot concentration. Some of the methods which have been tried are the dump shot in which the nitroglycerin has been poured into the hole opposite the sand, drilling of an oversize well, and the application of multiple shooting. The dump shot is undesirable both from a technical and safety standpoint and a large size well increases costs. The multiple shot has been given consideration and field tests have been made. Some Oriskany sand gas wells were given two successive shots at the time of drilling[12] and the effective radius determined after each shot. The results are given in Table 4. It can be noted that the second shot has an effect which is comparable to the first. It has been reasoned in the past that the first shot created a pattern of fissures which would reduce the capacity of the formation to conduct the energy of the second shot. If this were true the second shot would not be as effective as the first. The results given in the above table do not support this. The fissures created by the second shot are as effective as those produced by the first shot. In the case of Wells 7 and 9, the second shot seems considerably more effective than the first. The extremely large effective radius for the second shot on Well 9 is a bit difficult to explain. It may be due to the fact that the sand into which these wells are drilled is somewhat faulted and the fissures may penetrate through some of the faults. In these examples, it would appear that the second shot does not create fissures further away from the well than the first shot but only increases the effectiveness of the fissure pattern. Multiple shots have been tried in water flooding and reported in the literature.[5] The Clarendon Sand of Pennsylvania is very tight and must be shot as heavily as possible in order to inject water at an economic rate. The South Penn Oil Company in an attempt to obtain a maximum effective well radius, experimented with multiple shooting in the Clarendon area. One five-spot was chosen in which one well was cored, two inputs were given single shots and two inputs were given double shots. The water input data were then analyzed and the effective well radius calculated. The results are given in Table 5.

TABLE 5
Effect of Multiple Shot on Clarendon Sand

Well No.	FIRST SHOT		SECOND SHOT		
	Total Qts.	Qts./ Ft.	Total Qts.	Qts./ Ft.	r_w
05	120	4.5	..	..	12 ft.
09	120	4.5	..	..	7.9
017	120	4.5	90	4.5	5.3
018	120	4.5	90	4.5	9.2

An examination of these results indicates that within the experimental error to be expected in such tests and possible sand variation, the second shot did nothing to improve the effective well radius over the first shot. This is contrary to the experience with the gas wells. It will be noted that the shot responsiveness of the Clarendon sand is less than that for the Bradford and this poor shot responsiveness may be

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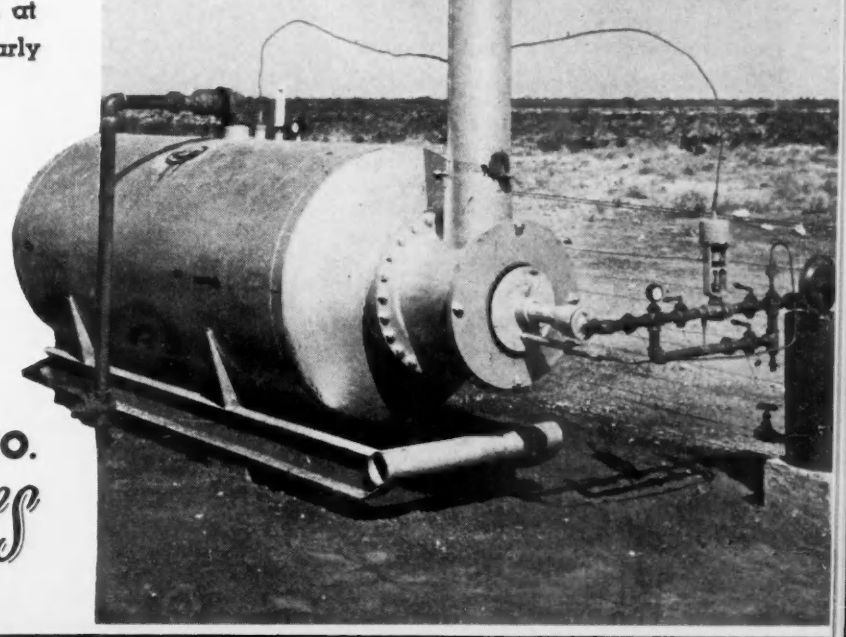

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part of the explanation for the poor results. The negative results on the Clarendon sand should not prevent experimentation with this technique on other sands in view of the success on gas sands.

If multiple shooting is successful it is possible to broaden the range of correctiveness. Theoretically, the maximum size shell would be equivalent to 7¾ inches which is the same as two 5½ inch shells. Corrective shooting charts could then be made on this new basis.

Tamping Process

Shots are usually tamped with water when shooting wells for water-flooding, the head of water varying directly as the number of quarts of nitroglycerin in the shot. Some work, although limited, has also been done with sand tamped shots and in some very rare cases a plaster of paris sealant has been used. The purpose of tamping is to confine the shot and therefore increase its effectiveness. Whether this is actually accomplished has not been proven as yet. According to some Bureau of Mines work on blasting referred to previously in this discussion,[9] the amount of tamping used had no effect upon the frequencies, wave shapes, or amplitude of the ground vibrations. In fact, the behavior with the untamped shots was the same as with the tamped shots. If these results would apply to the shooting of oil sands, it would mean that tamping has no effect on the effective radius.

In an attempt to compare the effect of a sand tamped with a water tamped shot an oil producer in the Bradford area shot six wells using sand tamping and the results on these wells were compared with the results of the surrounding water tamped wells. The average sand tamped shot contained 60 quarts while the average water tamped shot contained 95 quarts. The average cleanout time for the water tamped shots was about four days and there was no correlation between cleanout and shot size though the total shots varied from 60 to 100 quarts. The average cleanout time for the sand tamped shots was somewhat over nine days. There was no noticeable difference in behavior between the water tamped and sand tamped shots but the comparison was not quantitative. It is clear that sand tamping increases the shattering of the formation around the well bore but whether it gives a more effective fissure pattern and therefore a greater effective radius for a given shot concentration has not been proven as yet.

While some steps have been taken towards solving the problem of well shooting, a great deal remains to be done and in view of the importance to the oil industry, should be given more attention than it has received in the past. Some of the phases of the problem which are deserving of attention are as follows:

1. Effect of type of explosive. Some work has been and is being done on this but more is necessary.

2. The effect of type and quantity of tamping on the shot responsiveness of a sand should be given a quantitative study.

3. Multiple shooting should be investigated further.

4. Field data should be analyzed to determine the shot responsiveness of different formations.

5. Field tests should be made on the extent of correctiveness of a corrective shot with water input profile instruments.

6. Sands having directional permeability and shoestring sands would be benefited by a directional shot. It would be very helpful if such a shooting technique could be developed.

7. The shaped charge is receiving some attention in well shooting but there are no quantitative data available on its effect on the effective radius. Such studies should be made. The shaped charge would find application in directional shooting.

8. Field experimentation on shooting is both costly and time consuming. It would be very desirable to develop laboratory and semi-field scale techniques for investigating many of the phases of the problem. A laboratory test to determine the shot responsiveness of a sand would represent a great advance. It should be possible from a knowledge of the various properties of a sand such as compressibility, compressive and tensile strength, elasticity, wave propagating ability, etc., to predict the shot responsiveness of a sand. However, a large amount of experimentation will be necessary before this is accomplished.

Summary

A study has been made of shooting in water flooding and the following facts are indicated:

1. It is possible to increase waterflood spacing by shooting the wells and thereby increase profits by a reduction in development and operating costs. The harder the shot the wider is the possible spacing and the greater the profits.

2. A variation in the permeability of the strata in a formation which is being flooded can be corrected within certain limitations by shooting the tightest sand to the greatest extent and the more open sands to the least extent or not at all. An equation was derived and a chart drawn which enables the operator to obtain the shot distribution necessary to correct the permeabilities so as to cause them to flood at approximately the same rate.

3. The shot responsiveness of the sand on a lease in the Bradford area was determined by the analysis of field data. It was found that the effective well radius was approximately proportional to the shot concentration.

4. For a 300-foot spacing in a five-spot and assuming the shot responsiveness noted in Item 3, it was found that the maximum permeability ratio which could be corrected was about 4½.

5. The greater the spacing the less the maximum correctiveness possible.

6. In the analysis of some data on shot gas wells, it was found that there is some trend towards self correctiveness in which the lower permeability sands gave a higher effective well radius than the higher permeability sands with approximately the same shot concentration.

7. It was shown in the multiple shooting of some gas sand wells that the second shot was at least as effective as the first. Similar tests on the Clarendon sand showed no beneficial effects for the second shot.

8. Blasting studies and well shots with different tamping have not pointed definitely to any beneficial effects of the tamping. The cleanout time was much longer with a sand tamped shot than with water tamping.

9. A large amount of work remains to be done on the shooting problem and it is hoped that interested organizations will undertake some of the studies.

ACKNOWLEDGMENTS

The help of the Kendall Refining Company, Petroleum Reclamation Company, South Penn Oil Company, Ryder-Scott Company, and Hanley and Bird in the gathering of field data has been invaluable. The writer also wishes to acknowledge the many helpful discussions of this problem with numerous oil men and members of the petroleum production research staff of The Pennsylvania State College and the support of the Pennsylvania Grade Crude Oil Association in a portion of this work.

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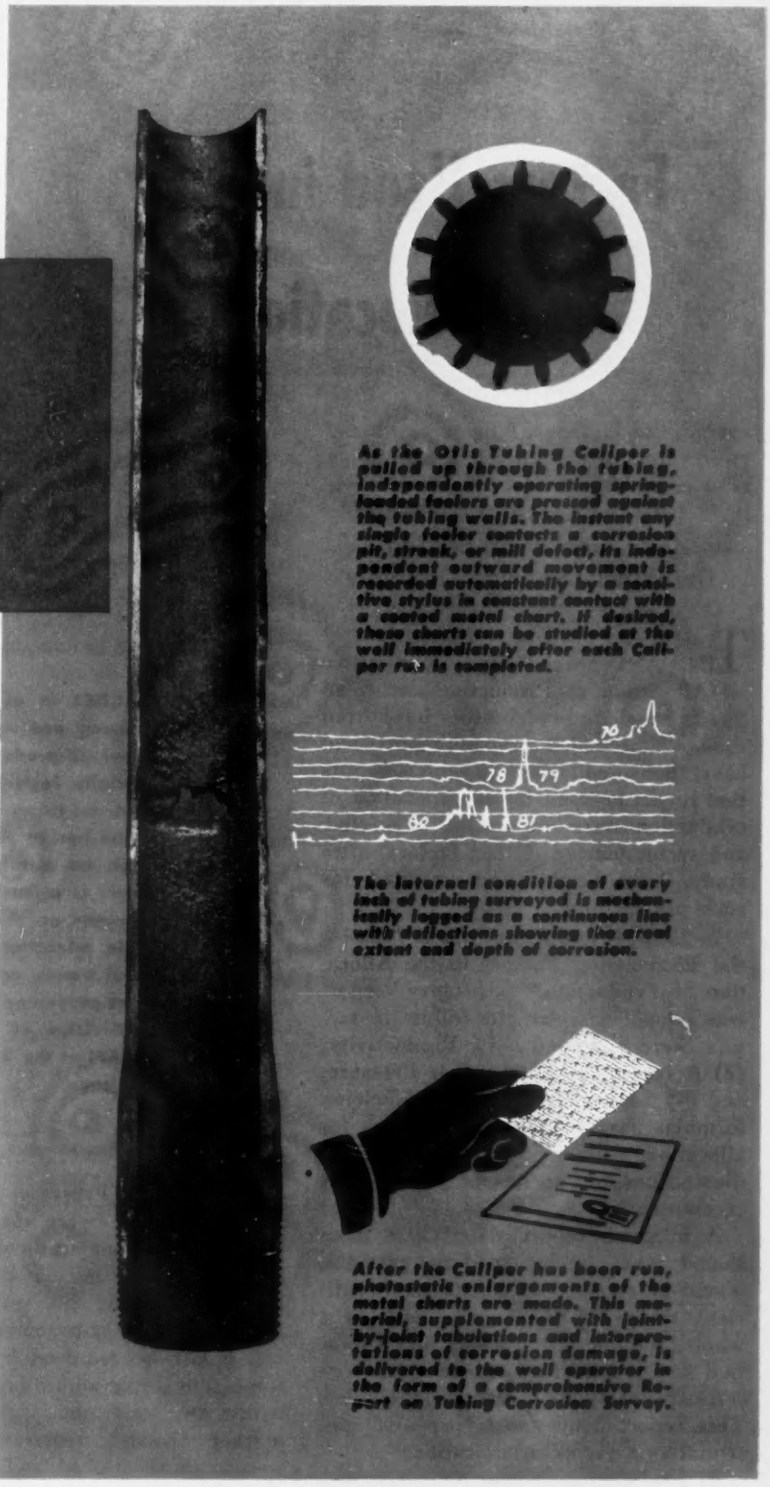

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Factors Used in the Allocation of Production Among Pools and Within Pools

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The Atlantic Refining Company

PRESENT PRACTICE in allocation of production among and within pools in the principal oil-producing states is reviewed briefly. Factors now used are compared to recommendations previously published by API committees. Although no detailed evaluation of factors is attempted, some general comments on the effect of such factors in allocation formulas, and on general trends, are included. This paper was presented November 9 before a Division of Production Group of the API at the 28th Annual Meeting in Chicago.

THE API Special Study Committee on Allocation of Production and Well Spacing and its predecessors have from time to time issued progress reports and have sponsored papers in which factors that might be used for the allocation of production were mentioned, suggested, and recommended. Other factors, after study, have been found unsuited for such use.

In 1933-34, under the title of "Essential Engineering Factors in the Allocation of Production,"[1] a progress report was issued in which the following factors were reviewed: (1) Productivity; (2) Acreage; (3) Bottom-hole Pressure; and (4) Sand Thickness. Some skeleton formulas having possible usefulness for allocation within pools were cited as illustrations, but no specific formula was recommended.

A progress report[2] dated 1938 mentioned what, under modern parlance, would be referred to as maximum efficient rate (MER) for the field as a whole. Ratable withdrawals and allocation so designed as to prevent drainage across property lines were recommended. This report condemned "per-well" potential as a factor in allocation.

In 1940 the committee discussed in a progress report[3] such factors as: (1) Reserves; (2) Market Demand; (3) Wells; and, (4) Depth, which might be used in determining allocations between states and fields within states.

In 1941[4] these same factors were again mentioned, with the addition of "MER" and the recognition that "acreage" in itself is some measure of "reserves."

The latest published progress report, titled, "Standards of Allocation of Oil Production Within Pools and Among Pools,"[5] was issued in 1942; and, in discussing allocation within pools, such factors as (1) Acreage; (2) Thickness; (3) Bottom-hole Pressure; (4) Potential; and, (5) Wells, were mentioned. The use of wells alone was condemned, unless specifically associated with a uniform well spacing. So, too, was "potential" as a factor questioned, although its use might be required by statutes in some states. For allocation among pools within any state such factors as MER, market demand, reserves, and depth were again mentioned, and recommendation made that such allocation be on some definite plan.

Summarizing, then, this committee has from time to time mentioned the following possible factors which might be used in a proration plan:

1. Productivity—In early reports; not now recommended.
2. Acreage.
3. Bottom-hole pressure.
4. Sand or pay thickness.
5. Reserves.
6. Market demand.
7. Depth.
8. Wells—Rejected unless provision made for uniform well spacing.
9. Potential—Rejected as unsound.
10. MER.

Of all these factors enumerated, present engineering thought would eliminate or greatly lessen the effect in allocation plans or formulas of "productivity," wells, and potential.

It is interesting now to survey conditions in the various oil-producing states to learn to what extent these various factors are being used. Such use is a measure of the degree of acceptance by the states, and also by the industry, of the engineering principles involved. Although it is true that the various regulatory bodies and the legislatures of the states formulate the rules, laws, and legislation upon which the various proration plans are based, there is, nevertheless, an observable tendency for those bodies to reflect a majority opinion of the industry as a whole; and, certainly, when there is unanimity within the industry, then the legislation and regulations ultimately conform in large measure to such opinion.

The following review of proration and allocation practices in the principal producing states is based on information supplied by members of the API Special Study Committee on Allocation of Production and Well Spacing. It reflects over-all practices in each state, and should not be considered statistically correct on any specific date.

Review by States

Arkansas: MER and "Market Demand" are the factors used in allocation among pools within the state. A study by B. J. Dowd, Union Producing Co., late in 1947 of 34 prorated fields showed six different combinations of factors, as shown in Table 1.

California: R. E. Loeck, California Research Corporation, and William R. Wardner, Jr., Conservation Committee of California Oil Producers, have sum-

marized allocation practices in California.

Distribution between pools: Under a voluntary program, "the Conservation Committee of California Oil Producers," elected by the operators, determines MER's monthly, which limits production in flush pools. The committee does not consider market demands or allocate production as such to pools.

Allocation within pools: A general formula and many special formulas include as factors: acreage, wells, thickness of pay, MER, pressure, and productivity index. Suitable correction factors are used for formation-volume factor, gas-oil ratio, and marginal or minimum credits in the determination of which "depth" is a factor. Most of the factors are used as multipliers rather than as additives, except that in many instances one-half of the pool's MER is divided on the basis of "wells" alone, and the other half on the basis of a formula.

TABLE 1

ALLOCATION METHOD	Number of Fields	Percent
Wells	22	64.7
Acreage—bottom-hole pressure	5	14.7
Reserves (volumetric)	3	8.9
Acreage (with gas-oil ratio limitation of 3500 to 1)	2	5.9
Wells—reserves	1	2.9
Acreage	1	2.9
	34	100.0

Except as noted, all field allowables are adjusted for gas-oil ratios in excess of 2000 to 1. 23 fields use well allowable; 8, acreage; 4, reserves; and 1, bottom-hole pressure.

In 1947, of 156 pools defined as having such characteristics that loss of ultimate yield will result from capacity production, 66 used a so-called "general formula." With it a minimum allotment is guaranteed to each well in the pool. The quantity increases with depth. The relative capacity, or maximum good operating rate, of each well is estimated and the remainder of the pool MER (i.e., MER less minimum allotments) is distributed to wells on the basis of the relative capacity (potential). In some cases a power factor less than one is applied to suppress large differences in relative capacity. The minimum allotment guaranteed is one barrel per day per 200 feet of depth to 1000 feet, then adding cumulatively one barrel per day for each 100 feet of additional depth—but no well to receive less than 10 barrels per day if capable of that production.

In 19 pools of this class which involve single-company or unit operations, only MER is assigned to the pool, and production distribution to the individual wells is left to the operator. Other pools use factors in the formulas as shown in Table 2.

In general, two or more of the foregoing listed factors are used in combination in an intrapool formula, depending upon individual pool characteristics and equity considerations.

Kansas: Allocation between pools: Productivity and acreage are used for fields whose total productive capacity is greater than market demand. Allocation is automatic, to a large degree, through a log-graph procedure.

Allocation within pools: Largely on the basis of productivity and acreage; however, not more than 30 acres can be allocated to any one well.

Louisiana: Dowd indicates that allocations by the Department of Conservation among pools within the state are based on "depth," each field being given a maximum allowable determined by wells times depth allowable. The table of depth allowables is as follows:

TABLE 2

FACTOR	Number of Pools
Wells	12
Acreage	16
Sand thickness	14
Bottom-hole pressure	17
Gas-oil ratio	10
Formation-volume factor	15
Productive index	1
Water cut	2
Top well limits:	
Oil, barrels per day	35
Gas, MCF per day	39

DEPTH (Feet)	Per-Well Allowable
0 to 2,000	76
2,000 to 3,000	90
3,000 to 4,000	109
4,000 to 5,000	128
5,000 to 6,000	151
6,000 to 7,000	177
7,000 to 8,000	204
8,000 to 9,000	228
9,000 to 10,000	261
10,000 to 11,000	295
11,000 to 12,000	330
12,000 to 13,000	365
13,000	410

The base allowable of the field may be further prorated among wells within the field by methods indicated in Table 3, which applied to 198 prorated fields in late 1947.

Michigan: W. B. Berwald, The Ohio Oil Company, under date of October 1947, reports:

"Regulation of oil production is by state regulatory bodies with the assistance of an advisory board to the supervisor of wells and individual operators themselves. Natural-gas production is regulated by the Michigan Public Service Commission, and is separate from oil regulation procedure. Inasmuch as a consideration of physical waste is the only statutory authority for the regulation of oil production, and as demand for oil has generally exceeded supply, cooperation of the various parties participating in the regulation of production has resulted in individual field

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EDGAR KRAUS was born in New York City and was graduated by Columbia University School of Mines with an E.M. degree in 1917. Entering the oil business in 1919, he has been active in petroleum engineering and geology as consultant. Prior to joining The Atlantic Company in 1921 he was with Pierce Oil Company. He is head of the geological section, Exploration Division, The Atlantic Refining Company, with headquarters at Dallas.

	RECOMMENDED							NOT RECOMMENDED			
	ACREAGE	BOTTOM HOLE PRESSURE	SAND OR PAY THICKNESS	RESERVES	MARKET DEMAND	DEPTH	MER	PRODUCTIVITY	PRODUCTIVITY INDEX	WELLS *	POTENTIAL
ARKANSAS	O	O		O	X		X			O	
CALIFORNIA	O	O	O				X O		O	O	O
ILLINOIS					X						
KANSAS	X O							X O			
LOUISIANA	O	O				X O				O	O
MICHIGAN					X					O	
MISSISSIPPI	O						X				
NEW MEXICO	X O	O			X	X O					
OKLAHOMA	O	O	O		X		X	O	O	O	O
TEXAS	X O	O	O	O		X	X			O	O
WYOMING ETC					X					O	

* IF ALLOCATION IS TO WELLS – ON UNIFORM SPACING – EFFECT IS SAME AS ALLOCATION ON BASIS OF ACREAGE
X FACTOR USED IN ALLOCATION AMONG POOLS WITHIN STATE
O FACTOR USED IN ALLOCATION WITHIN POOLS

FIGURE 1. Allocation factors used in various states.

rates as high as possible without waste. With perhaps a few exceptions, allocation between fields has been unnecessary, except possibly to make per-well allowables more uniform in prorated fields. Allocation to individual wells has been on a per-well basis; and, as spacing regulations have been strictly enforced, allocation has been equivalent to acreage allocations. There has never been any modification of well allowables for potential, sand thickness, structural position, or other factors. During the war, when spacing was changed from 20 acres to 40 acres, the 40-acre well allowables were 1.75 times the 20-acre well allowable. In view of the limited supply, and to encourage exploratory drilling, discovery wells are not prorated so long as there is no physical or market waste. Several wells may be drilled in a new field before official proration orders are issued."

Mississippi: During 1948 legislation became effective creating a Mississippi State Oil and Gas Board. This five-member board has the power to hold hearings, issue and enforce rules and regulations adequate to prevent waste, and also fairly and equitably to allocate production among pools and within pools. The members of the board are appointed—three by the governor, one by the lieutenant governor, and one by the attorney general of the state.

At this writing (September, 1948) statewide rules and regulations and proration orders have not as yet been published, so that the actual factors which will be used in allocation are not known. However, the law creating the board specifically prohibits the use of market demand as a method of allocation to the various pools and fields or to tracts within a pool.

Preliminary proposals indicate that acreage will be an important factor in allocation within pools, and that MER is being considered as a major factor in allocation among pools.

New Mexico: Allocation between pools: The over-all state allowable for New Mexico is determined by the Oil Conservation Commission, which consists of the governor, state land commissioner, and the state geologist. It determines this allowable largely on the basis of market outlet and market demand, and is reported also to consider the ability of the various pools to produce without excessive waste. It is not clear how this latter factor is determined.

Fields in the northwestern portion of the state are permitted to produce without restriction. Fields in Eddy, Lea, and a portion of Chaves counties are subject to proration which works automatically once the over-all state allowable has been determined. Total marginal production from wells incapable of producing the daily state top allowable within their depth bracket is first determined from previous production reports and nominations, and is deducted from the total state allowable set by the commission. The remainder is divided by the number of 40-acre units capable of making their allowables, and this quotient then becomes the daily state top allowable. In addition, a depth factor is introduced which modifies the allowable for deep pool units. Table 5 gives these proportioning factors.

The allocation to any pool, therefore, becomes the total number of top allowable producing 40-acre units times the daily state top allowable (modified by the depth factor if producing below 5000 feet) to which is added the marginal allowables from those wells unable to make top allowable.

The only factors used in interpool allocation are producing acreage and depth.

From an engineering viewpoint, the use of only these two factors might be seriously questioned; however, in practice the system has worked well and the operators as a whole have been well satisfied. Wide spacing and relatively low allowables have been effective in preventing any glaring inequities.

Allocation within pools: Within any one field, adjustments are made for high gas-oil ratio, and such wells are penalized. The penalty oil is re-allocated within the same field to other wells capable of producing it without excessive ratios.

Some fields have intrapool allocation formulas which have factors other than "producing units" (acreage). In Monument field the allowables are determined 80 percent on acreage and 20 percent on bottom-hole pressure in excess of an average base. In Hobbs field the factors are 80 percent acreage and 20 percent on the actual observed bottom-hole pressures. In most of the other fields, except for the gas-oil ratio adjustment, allocation to the individual units is on the basis of acreage alone.

Spacing has given little or no problem in New Mexico, the 40-acre proration unit having been established early, and only in very shallow pools has there been any drilling at greater density than one well to 40 acres.

As indicated previously herein, although the proration system may not be so well designed from an engineering standpoint as might be desired, it has proved to be satisfactory to the operators. Its automatic feature has made it possible for each operator to calculate what his allowable will be, and the depth allowable has encouraged the exploration for and development of deep production.

Oklahoma: H. H. Kaveler, Phillips Petroleum Company, contributes the information on Oklahoma:

"Establishment of pool allowables: Pools in the state of Oklahoma are classified as 'allocated' or 'non-allocated.' There is no minimum well allowable fixed by law in the state. Each month the Corporation Commission, upon hearing, determines both the current market demand for oil and gas, and the amount of that demand that can be produced without waste and without unreasonable discrimination between allocated pools. In fixing daily production of an allocated pool in any month, the proceeding does not take the form of fixing a 'MER' rate

TABLE 3
Probable Fields for Which Allocation Orders Have Been Written
December 23, 1947

LOUISIANA

ALLOCATION METHOD	Number of Fields	Percent of Fields
Basic (depth bracket only)	160	80.9
Acreage	26	13.1
Well and acreage	2	1.0
Acre-pounds	6	3.0
50 percent acreage and 50 percent potential	1	0.5
50 percent acre-pounds and 50 percent potential	1	0.5
50 percent well and 50 percent bottom-hole pressure	1	0.5
University Field (see Table 4)	1	0.5
	198	100.0

TABLE 4
University Field—Allocation Methods by Sands

ALLOCATION METHOD	Number of Sands	Percent of Sands
Acreage	5	41.67
Acreage and potential (percent varies with lifting methods)	1	8.33
Basic	5	41.67
Special (in exception to order No. 45-I)	1	8.33
	12	100.00

TABLE 5

POOL DEPTH RANGE (Feet)	Proportional Factor
From 0 to 5,000	1.00
Below 5,000 to 6,000	1.33
Below 6,000 to 7,000	1.77
Below 7,000 to 8,000	2.33
Below 8,000 to 9,000	3.00
Below 9,000 to 10,000	3.77
Below 10,000 to 11,000	4.67
Below 11,000 to 12,000	5.67

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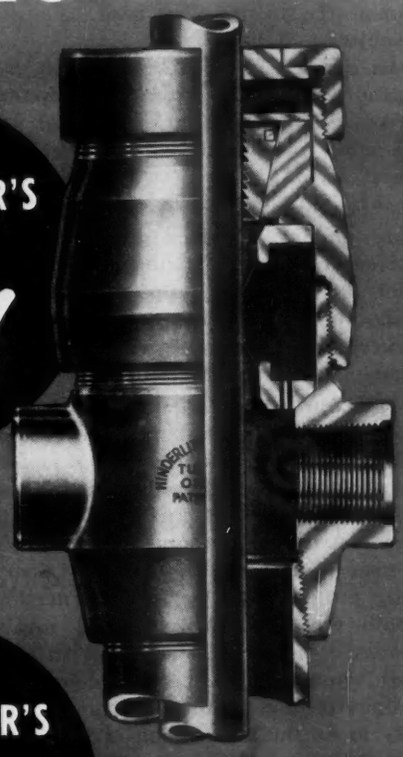

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as such. The allowables each month are determined by conditions currently existing.

"Allocation within pools: Production is allocated to individual wells under the general rules of the Corporation Commission. Factors considered in determining the allowables of individual wells within a pool are 'per-well,' potential, productivity indices, acreage in the drilling unit, thickness of pay zone, bottom-hole pressure, producing gas-oil ratio, and producing water-oil ratio. Practically, every allowable is based upon the fixing of a basic allowable, subject to a limiting gas-oil ratio—with the order written in such manner that production is permitted daily up to a fixed number of barrels of oil, or fixed number of cubic feet of gas, whichever first occurs.

"Since most of the pools in the state are uniformly spaced under the provisions of the well-spacing law, allocation for all practical purposes amounts to allocation on a drilling-unit acreage basis except for wells penalized for excessive gas-oil ratio or water-oil ratio.

"Features of Oklahoma conservation practices: The Oklahoma law provides for the fixing of drilling units of uniform shape and size, with wells drilled thereon on a uniform pattern throughout the pool. After the Corporation Commission (upon hearing) finds and orders a spacing program, the separate ownerships, both working-interest and royalty-interest, in each drilling unit so fixed, are automatically consolidated—with the commission given the power and authority to fix the termination of the 'operating agreement' between the parties in the event the parties cannot mutually agree thereto. The reasonable and constructive administration of the statute has done much toward effecting a greater measure of conservation practice, and has minimized the drilling of unnecessary wells in the state.

"An effective provision of the revised spacing law is the provision that prohibits the drilling of any well into any common source of supply during the period that an application for spacing is pending before the commission, except that such wells be drilled after hearing and the granting of an exception by the commission.

"Oklahoma has given much attention to gas conservation. This is accomplished by fixing gas-oil ratio limitations in all newly discovered fields and in many of the older fields. The conservation of gas is also effectively accomplished under a general rule of the commission that all 'discovery wells' are automatically granted a 'discovery allowable' of 150 barrels per well daily of oil, or ½ million cubic feet of gas daily, whichever is first produced. Such discovery allowable remains in effect for a period of 60 days from the date of first production—after which it is automatically terminated, unless the operators present to the commission, in hearing, evidence upon which an allowable can be fixed after that 60-day period. Such a discovery allowable rule encourages the operator to obtain basic essential information on discovery wells to the point that a conservation program can be designed from the beginning of production.

"The Corporation Commission in recent orders has adopted the principle of fixing allowables as between tracts, on the principle of granting 'equivalent volumetric withdrawals' from the reservoir to each separate drilling unit. This, in fact, is the principal factor in setting the limiting gas-oil ratio which fixes the maximum production from any allocated drilling unit.

"The state of Oklahoma continues to lead in the adoption of effective conservation practices. This is again demonstrated in the 'pool unitization law,' created by House Bill 339 of the 1945 legislature. Under this statute the commission, upon hearing and upon finding in the absence of veto of the order by 15 percent ownership in acreage, may order the unitized management and operation of any common source of supply when it is found necessary properly to utilize reservoir energy and to obtain the maximum ultimate recovery.

"On July 28, 1947, the Oklahoma Corporation Commission, acting under House Bill 339 of the 1945 legislature, approved a plan of unitization for the West Edmond Hunton Lime field. The West Edmond Hunton Lime Unit operation became effective October 1, 1947. It was followed by the formation of the West Cement Medrano Unit on December 1, 1947, and by the Southwest Antioch Gibson Sand Unit on April 1, 1948, and by the granting of an order forming the Chitwood Unit effective on March 29, 1948. Each of these unit operations will substantially increase ultimate recovery of oil, and accomplish the conservation of a large reserve of gas."

Allocation in Texas

Texas: T. A. Huber, Humble Oil & Refining Company, reviews in detail present trends in allocation in Texas:

"Allocation among pools: The Texas Railroad Commission, a body of three elected commissioners, regulates production in the state. For the more important fields, MER is the controlling factor in allocation to pools. Allocations are essentially on a uniform percentage basis of field MER's. For the smaller fields on which the Railroad Commission has not set MER's, the old 'yardstick' of depth and acreage still applies to a considerable extent. MER's are determined after Railroad Commission hearing at which all operators have the opportunity of presenting evidence. New wells in new fields continue to have discovery allowables that are dependent upon depth and MER.

"The Railroad Commission in establishing MER's has held public hearings for the stated purpose of determining 'the highest productive capacity that can be obtained without causing preventable waste.' The commission has required the submission of data on reservoir pressure, gas-oil ratio, salt-water production, and rate of oil production; these data to reflect, where available, average reservoir values for each reservoir, and preferably to be submitted for periodic intervals during the producing life of the reservoir or, at least, to cover periodic intervals during the immediately preceding four years. It is further suggested that additional information on each reservoir within a field, such as average porosity, average permeability, type of energy drive, and productivity indices be furnished if available.

"The commission suggests that operators in each field confer with each other so that such data may be assembled and presented with respect to reservoirs as a whole rather than with respect to particular leases, and that one operator be appointed to submit such reservoir data at the hearing. Each operator, however, is requested to submit his own recommendation as to the maximum efficient rate of production.

"Of the 1214 fields included in the Railroad Commission September, 1947, schedule, 483 (40 percent) have been assigned MER's by the commission. The sum of the MER's for these fields, and including the East Texas field, amounted to 2,047,000 barrels, compared with the state of Texas August daily average production of 2,306,000 barrels, or 88.7 percent of the production. The MER total includes rates for a number of stripper fields that were established at or near their productive capacity, but which account for only a very small portion of the total MER.

"Allocation within pools: Table 7 lists the various methods of intrapool allocation in effect in 372 Texas fields for which allocation formulas have been prescribed. For these fields, there has been only one order prescribed since January, 1943, that did not give 50 percent or more credit to acreage. Only two formulas have been used during 1946 and 1947, viz., 50A + 50W and 75A + 25W. These two formulas account, respectively, for 63 (50 percent) and 57 (45 percent) of the total of 126 allocation orders prescribed since January, 1943. It is noteworthy that for only 15 of the 372 fields there is given no credit for acreage. Omitting seven fields with slightly different bases of allocation,

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the distribution in order of credit given to acreage is as in Table 6.

"The remaining credit was distributed in varying proportions among wells, bottom-hole pressure, and potential factors—with the well factor predominating. Considering the formulas adopted during the past few years, it appears that acreage and other such volume factors are at least holding their own or gaining slightly in consideration.

"Although there has been a trend away from the use of potentials as a basis for allocation, with two formulas employing potential factors rescinded during 1947, there are still three based wholly on potential, and 47 others include a potential factor. Twelve fields use bottom-hole pressure in the allocation formula. Among the miscellaneous categories are one field allocated on the basis of reserves and one each having factors for depth and acre-feet. The usual consideration is given to marginal and high gas-oil ratio producers, and suitable corrections made.

"Important changes and decisions affecting allocation formulas: During 1947, several decisions and innovations in allocation formulas took place which may have an important bearing on future formulas. Noteworthy were: (a) the adoption of formulas at Stratton and Old Ocean which permit owners of gas caps overlying oil zones to have current income without dissipation of the gas cap before the oil is recovered; and, (b) the Hawkins proration suit to obtain relief from drainage of oil to a densely drilled townsite.

"Stratton allocation order: The Bertran and Wardner oil reservoirs of this field have large gas caps which have been cycled for a number of years. A unique proration order has been adopted for these reservoirs in an attempt to promote conservation by preventing dissipation of the large gas caps and at the same time to promote equity by permitting owners of gas-cap properties to secure current revenue. For oil operations, the order provides that ratios in excess of the solution ratio be penalized, and it requires return of all produced casinghead gas to the formation before the penalties are completely removed. For gas operations, the order permits production calculated to result in reservoir voidage per acre of gas cap equal to the reservoir voidage per acre of the oil zone. It is further provided that the Railroad Commission may permit voluntary conversion of the gas allowable so calculated to an oil allowable on an equivalent value basis, plus sufficient additional oil to compensate for the cost of lifting the oil if produced on the same lease, and also to meet royalty payments if produced on different leases. This order is in addition to that under which cycling operations are being conducted.

"Old Ocean allocation order: Cycling and oil-production operations are under way, with both the oil and gas interests of the operators being unitized. A Railroad Commission order issued August 20, 1947, for the Armstrong and Chenault sands of this field follows, in general, the pattern of the Stratton order but, in addition, provides that:

"1. Allowables of high gas-oil ratio wells may, at the election of the operator and with approval of the Railroad Commission, be transferred to any other well or wells producing from the same reservoir on any lease operated by himself or by other operators.

"2. Gas allowables of gas-cap wells subject to Railroad Commission approval may be transferred to any other gas-cap well producing from the same reservoir on any lease, whether operated by himself or others.

"3. A bonus allowable not exceeding one-tenth of the basic allowable will be given for injection of extraneous gas to the gas cap."

"'M. H. Dubrow, Continental Oil Company, points out that Hildreth field (No. 2 conglomerate unit) in Montague County, Texas, has operated under an order since December 1, 1946, which permits the entire daily oil allowable of the pool to be produced from the most efficient wells. The entire area of the unitized gas-injection project was considered to be one lease. This is thought to be one of the earlier orders which permitted transfer of allowables so as ultimately to benefit the entire pool and to allocate production to wells within the unitized area on the basis of engineering factors.'

"Hawkins proration suit: The allocation formula adopted by the Texas Railroad Commission for the Hawkins field credits 50 percent to acreage and 50 percent to wells, with the further provision that a well on 20 acres (the proration unit adopted by the commission) will not produce more than twice the allowable of a well on less than one acre. With the exception of the Hawkins townsite, the field is drilled on a 20-acre pattern. In the townsite, an area of 73.7 acres contained 87 wells at the time of the suit. The formula allowed these 87 wells to produce 4147 barrels daily, or 9.3 percent of the field allowable, although the 73.7-acre area contained only 1.5 percent of the recoverable oil in the field.

"In the suit, a large operator and some owners of royalty in large tracts sued to enjoin enforcement of the formula upon the ground that it resulted in confiscation of their oil. Trial before jury in the district court resulted in a judgment decreeing the formula to be confiscatory and, therefore, invalid. However, the Austin Court of Civil Appeals reversed the lower court's judgment and upheld the formula. The appellate court held that, although the formula undoubtedly resulted in the drainage of plaintiff's properties, that fact was not enough to invalidate the formula, because the plaintiffs were compensated for the loss of oil by 'savings' which flowed from the 20-acre spacing rule. The court did not mention the royalty owners. The Texas Supreme Court and and the U. S. Supreme Court have declined to review this decision." (See Table 7.)

Wyoming and Other Rocky Mountain States: Berwald's comments follow: "Allocation of production among pools and within pools is essentially on a voluntary basis. Available oil production has often exceeded the demand and pipe-line outlet capacity. Production from individual pools has depended largely on market demand for the vari-

TABLE 6

ACREAGE IN FORMULA (Percent)	Number of Fields
25	8
33⅓	7
50	177
60	4
66⅔	2
75	116
100	36

TABLE 7

Proratable Fields for Which Allocation Orders Have Been Written, State of Texas

Allocation Method	Nov. 1, 1947		Orders Issued Since Jan. 1, 1947	
	No. of Fields	Percent	Fields	Percent
P	3	0.81	..	...
W+P	8	2.15	..	...
M+P	3	0.81	..	...
W+depth	1	0.27	..	...
A+B	1	0.27	..	...
X+5 percent A	1	0.27	..	...
25A+75P	1	0.27	..	...
25A+75W	7	1.88	..	...
¼A+¾W	2	0.54	..	...
⅔A+⅓P+⅓W	2	0.54	..	...
⅓A+⅓B+⅓W	3	0.81	..	...
50A+30B+20W	1	0.27	..	...
50A+50B	4	1.08	..	...
50A+25P+25W	2	0.54	..	...
50A+50P	24	6.45	..	...
50A+50W	146	39.23	12	43
60AP+40W	1	0.27	..	...
60A+40W	4	1.08	..	...
¾AP+¼W	1	0.27	..	...
⅔A+⅓W	2	0.54	..	...
75AB+25W	1	0.27	..	...
75A+25P	5	1.34	..	...
75A+25W	110	29.55	16	57
75A+25B	1	0.27	..	...
AH+B	1	0.27	..	...
100 A	36	9.68	..	...
Reserves	1	0.27	..	...
Total	372	100.00	28	100

A—acreage. B—bottom-hole pressure. H—Sand thickness. M—marginal. P—Potential. W—well. X—basic allowable.

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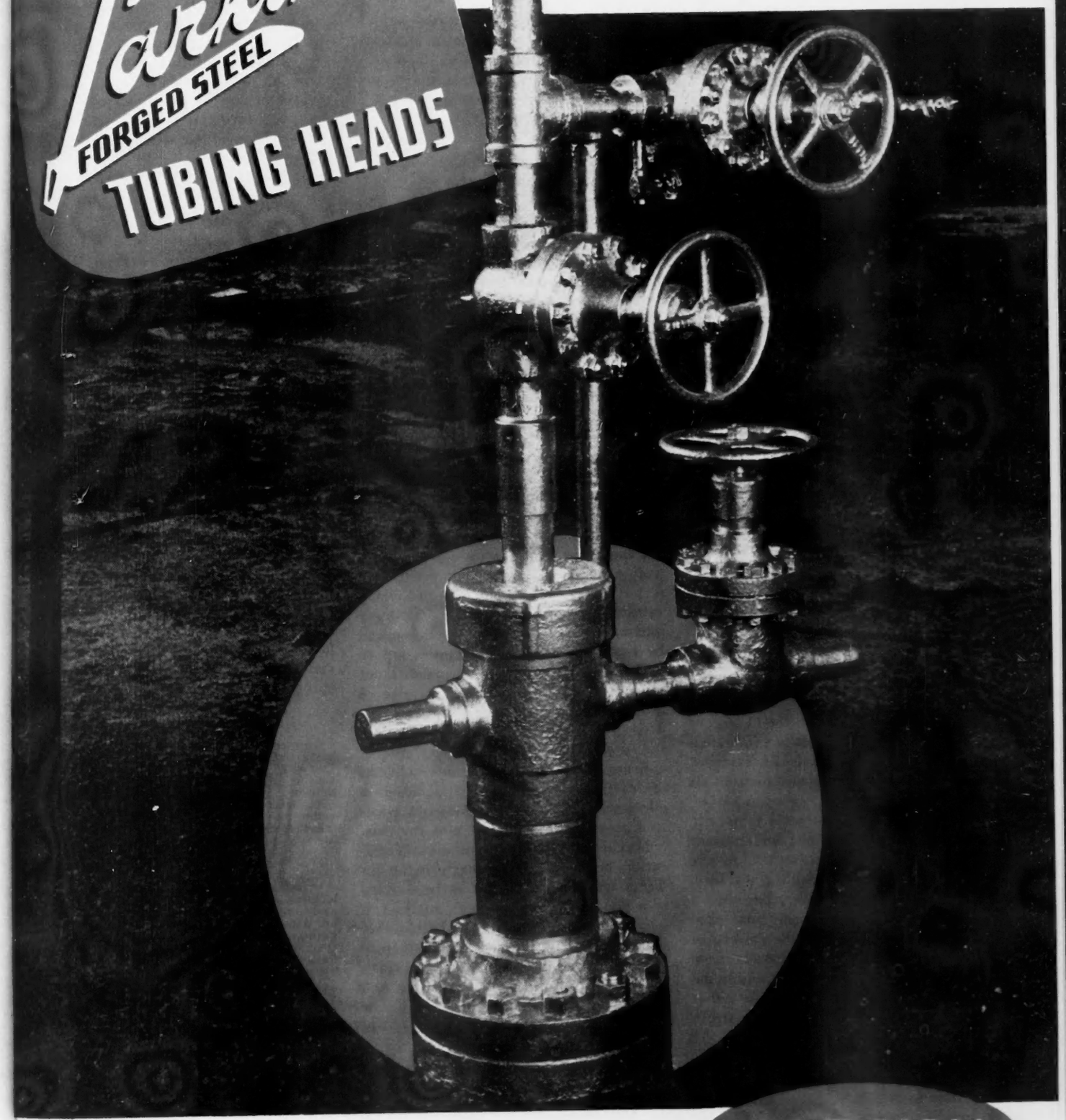

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ous types and grades of oil available. Allocation of production within pools has usually been on a per-well basis by voluntary agreement between the operators. Many pools are on lands subject to supervision by the U. S. Department of the Interior or by the various states, and these agencies participate to appreciable extent in the regulation of production. However, there is no legislation pertaining to regulation or allocation of oil or gas production in these states. Many pools are operated under unit plans, with acreage as a basis of participation and production controlled to obtain efficient recoveries from the reservoirs. In other pools, field allowables and well allowables are controlled by mutual agreement and cooperation between operators. In most pools, however, rate of production is as high as market demand and pipeline outlets will allow without excessive waste. Trends during the past two or three years have been toward more unit operations and more efforts to regulate production to obtain greater recovery efficiencies."

Summary

It would appear that acreage as a factor in allocation has been recognized in all of the states which attempt to allocate production. In many instances it is used without any other qualifying factors, as in the case of fields which are prorated on 100 percent acreage. The use of a single acreage factor presupposes that all leases within a pool are underlain by the same quantity of oil per unit area. In most oil fields this would be an exceptional condition. When wells alone are used, and when a uniform spacing is adhered to, allocation is the same as it would be on 100 percent acreage. If uniform spacing is not prevalent, allocation on the basis of wells alone tends to result in production on the basis of the "rule of capture" rather than to give to each operator his proportionate share of the "oil in place." The use of wells in a formula is usually justified on the score that an operator should be entitled to a return on the investment involved in drilling the well. When this factor, however, becomes a significant percentage of the total allocation, then it encourages the drilling of unnecessary wells, as has already been indicated, merely to obtain additional allowable. The final outcome is either a poorly distributed drainage pattern or the drilling of unnecessary wells by all the operators in the pool.

Bottom-hole pressure as a factor in allocation is usually proposed as a means of avoiding undue pressure differentials between wells or leases, but the bottom-hole-pressure factor commonly employed is too small to prove effective in this regard. If the pressure factor is used in a formula as a multiplier rather than as part of an addition of factors, then its effect is more noticeable.

Engineers in general have concluded that potentials are not a direct measure of reserves under a tract or lease; they are, moreover, difficult to determine in such a way as to avoid discrimination. Even though taken under standardized conditions, they result in waste and fail to give to each operator an allowable rate of production which will return to him currently his share of the "oil in place." Its use in proration formulas is definitely decreasing.

Productivity index is used infrequently in California and Oklahoma, and then only as a minor factor.

Thickness of pay which, together with acreage gives a volumetric measure in an allocation formula, is used only to a very minor extent at this time. Increased use of this factor would do much to give engineering completeness to many of the allocation plans now in vogue. When volumetric formulas, either straight or modified, are used for allocation within pools in California, the "formation-volume factor" is included. In many other states an attempt is made to accomplish the same volumetric withdrawal by regulations which control gas-oil ratios or total gas production, water production, etc.

Inasmuch as the cost of a well is, in some measure, proportional to its depth, the use of the depth factor appears justified, provided the resulting production is not in excess of efficient producing rates. However, some economists argue that allocation should not be influenced by cost; and that, if it is necessary to drill deep wells in order to maintain our crude supply, then the market price of crude should reflect such added costs. This problem does not seem to be within the province of the engineer; and it appears that, under present conditions at least, depth might well be used in allocation of production between pools to a greater extent than is now the case.

Maximum efficient rate is used in allocation between pools usually in an indirect way, in that it limits production of a pool. Its use as a direct method of allocation between pools has been somewhat delayed by the lack of satisfactory methods for its determination in all types of pools. California's determination and use of MER is outstanding. Texas now uses MER as an important factor in such allocation.

Reserves, although not often used directly, have some reflection in MER; and, insofar as that factor is used in allocation, reserves are represented. Considerations other than engineering sometimes prevent use of reserves as such in allocation plans.

Therefore, it is apparent that various states use all of the factors, summarized in the early part of this paper, which the committee has indicated might be used in an allocation plan. Unfortunately, they also use such factors as productivity, potential, and wells—which the committee does not strongly recommend and, in fact, condemns under certain conditions. It would appear that progress might be made in the way the factors are used, rather than in further complicating allocation plans by intricate formulas which include many factors. A greater use of multiple, rather than additive, formulas would tend more nearly to give the desired result, viz., when possible to give to each operator currently his proportionate share of the oil in place within the reservoir.

Figure 1 shows graphically the factors used in various states in allocation of production among pools and within pools. It emphasizes the fact that improvement in allocation practices can still be made. During the present period of high demand, with the attendant decrease in need for unduly severe restriction of production, proration and allocation become a minor problem. Its study at this time from an engineering standpoint is especially desirable, because the heated controversy concerning proper factors has cooled apace with the easing of urgency. The time may again come, however, when restriction of production will be necessary—not only as a conservation measure, but to balance production and market demand, and for the purpose of avoiding waste because of excessive overground storage. It is hoped that at such time factors used in all the oil-producing states will reflect careful engineering study and recommendations.

ACKNOWLEDGMENT

This compilation has been made possible by the assistance of past and present members of the API Special Study Committee on Allocation of Production and Well Spacing. Many helpful contributions and comments have been received from present members of that committee in addition to those specifically mentioned. To all of them, the writer extends his sincere thanks.

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Oil Production by Gas and Flooding

By PARK J. JONES
Consultant, Houston

Part 4. Displacement of Oil by Gas

THIS article considers displacement of oil by gas at, or above, the saturation pressure for an oil. Gas-oil ratios of about a million cubic feet per barrel for the production from any section in a reservoir are required in order to displace that fraction of in place oil which is displaceable by gas.

A Uniformly-Permeable Section

Pass a plane through a reservoir at some level below a gas-oil contact. Such a section cuts numerous beds and may have a considerable strike distance within a bed. By virtue of variable permeability as between beds and points within a given bed, the permeability of a section through a reservoir is variable. First consider the portion of a section which is limited to a very short distance in one thin bed and call this a uniformly-permeable section.

Relative Permeability

Force gas into a uniformly-permeable section at a pressure not less than the saturation pressure for an oil. The relative permeability K_o to a reservoir liquid and K_g to a gas are defined[1] approximately by

$$K_o = (1 - C)^3 \qquad (1)$$

and

$$K_g = 1.23(C - 0.1)^3 \qquad (2)$$

were C is displaced oil expressed as a fraction of initially in place oil within a uniformly-permeable section.

The curves in Figure 4-1 are solutions of equations (1) and (2).

Gas-Oil Ratio

Let R_o be the gas-oil ratio for the production from a uniformly-permeable section. When measured at reservoir conditions,

$$R_o = \frac{bQ_g}{Q_o} = b\,\frac{\mu_o}{\mu_g} \cdot \frac{1.23(C - 0.1)^3}{(1 - C)^3} \qquad (3)$$

where

b = volume factor for oil, bbls/bbl
μ = viscosity, centipoises
Q = producing rate, bbls/day.

The volume factor for a gas is 5.04TZ/P barrels per MCF, where P is absolute reservoir pressure, T is absolute temperature and Z is the compressibility factor.

Accordingly, the gas-oil ratio in standard cubic feet of gas per barrel of stock tank oil is given approximately by

$$R_o = \frac{198 \cdot 4bP\mu_o}{TZ\mu_g} \cdot \frac{1.23(C - 0.1)^3}{(1 - C)^3} \qquad (4)$$

The first expression on the right side of equation (4) is the pressure-fluid factor for displacement of oil by gas and is denoted by F.

The curves in Figure 4-2 are solutions of equation (4). Gas-oil ratios are aside from solution gas. The data are for 100 percent displacement efficiency, that is, no gas passes through without displacing oil.

Breakthrough Recovery

The oil displaced from a section at the time the section starts producing gas is called the breakthrough oil recovery U_b. The approximate breakthrough recovery is given by

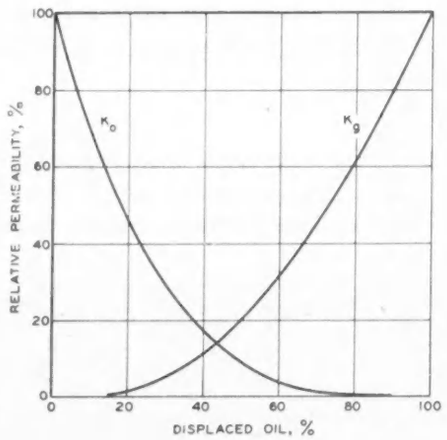


FIGURE 4-1. Relative permeability to gas and reservoir liquid vs. the displaced oil from a uniformly-permeable section.

$$U_b = 20 - \left(\frac{\mu_o}{\mu_g}\right)^{1/2} \qquad (5)$$

Maximum Oil Recovery

The oil displaceable from a section with a practical total volume of gas through the section is called the maximum oil recovery U_o. A section at any level in oil has variable permeability. Consequently, gas migrates through localized portions of a section. The localized portions of sections are channels or paths having comparatively high conductance. Field experience indicates that the oil recovery from a section as a whole is not likely to exceed the recovery defined by

$$U_o = 70 - \left(\frac{\mu_o}{\mu_g}\right)^{1/2} \qquad (6)$$

B and M Contours

The position of a breakthrough section in a reservoir is denoted by a contour called B. The position of a maximum recovery section in a reservoir is indicated by a contour called M. The dip distance between a B contour and its M contour varies with the distribution of pay and permeability in a reservoir. Per-bed rate of gas injection and oil production are influencing factors also.

Convergence of Reserve

Pass a horizontal plane through a reservoir at some elevation above the level of the downdip productive limit. The intersection of the plane with the top of pay defines a contour. Let A equal the productive area within the contour.

Pass another horizontal plane at a level which is lower than that of the first plane. Let "a" be the productive area within the second plane. Then convergence of reserve C is defined approximately by

$$C = \frac{2A}{A + a} \qquad (7)$$

The Displacement Factor

Figure 4-3 will be used to derive the displacement factor m for a B-M region. Denote the position of an M contour by zero. Let A equal the productive area within M. Let B equal the distance along top of pay from M to its B contour. Let "a" equal the area within the B contour. The area a_x enclosed by a contour X at any level between M and B is given by

$$a_x = A - (A - a)\frac{X}{B} \qquad (8)$$

aside from abnormal changes in pay thickness, dip or length of strike. The oil displaced from the area enclosed by an X contour is defined approximately by

$$U_x = U_o - (U_o - U_b)\frac{X}{B} \qquad (9)$$

The acre-feet of pay in the vicinity of the area a_x is proportional to $a_x dX$. The acre-feet of pay within a B-M region is proportional to $B(A + a)/2$ aside from abnormal structural or stratigraphic changes. Hence, the displacement factor m is defined approximately by

$$m = \frac{\int_0^B U_x a_x dX}{B(A + a)/2}$$

Upon integrating, we have

$$m = U_o\left[\frac{2A + a}{3(A + a)}\right] + U_b\left[\frac{A + 2a}{3(A + a)}\right] \qquad (10)$$

From equation (7), the area enclosed by a B contour is defined approximately by

$$a = \frac{A(2 - C)}{C} \qquad (11)$$

Eliminate "a" between the two foregoing equations and obtain

$$m = \frac{1}{6}\left[U_o(C + 2) + U_b(4 - C)\right] \qquad (12)$$

Upon substituting the right side of equations (5) and (6) for U_b and U_o respectively, we have

$$m = 36.7 + 8.3C - \left(\frac{\mu_o}{\mu_g}\right)^{1/2} \qquad (13)$$

which is the desired displacement factor expressed in terms of structural and stratigraphic conditions and viscosity ratio. For C equal to unity,

$$m = 45 - \left(\frac{\mu_o}{\mu_g}\right)^{1/2} \qquad (14)$$

On the other hand, under some abnormal structural or stratigraphic conditions for which a gas-oil interface spreads out over an area which is very large compared with the area of an M contour, convergence approaches zero and we have

$$m = 36.7 - \left(\frac{\mu_o}{\mu_g}\right)^{1/2} \qquad (15)$$

The latter condition exists initially in the vicinity of an injection well.

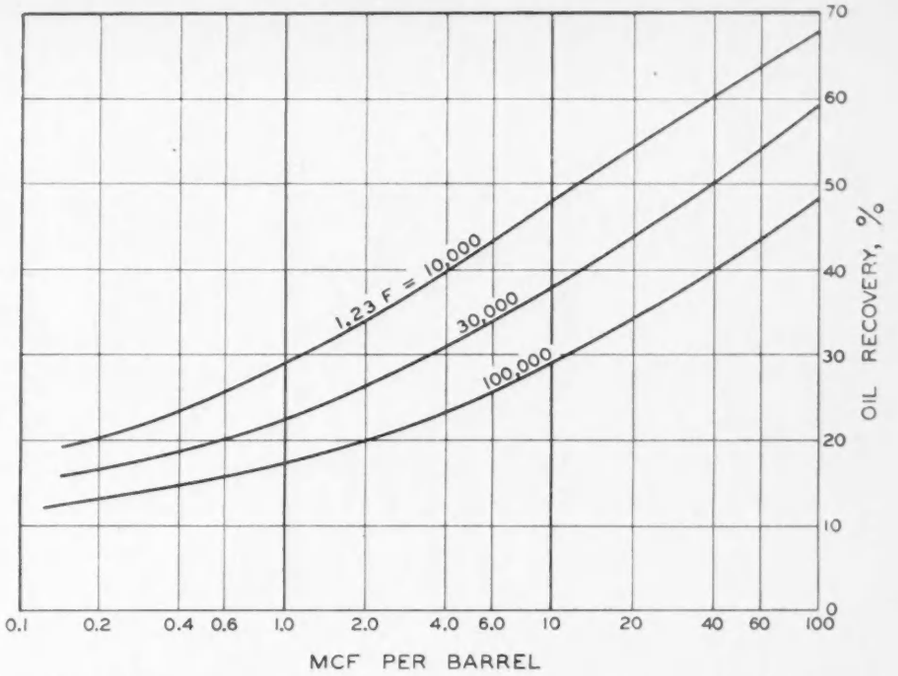


FIGURE 4-2. Oil recovery vs. pressure-fluid factor F and the gas-oil ratio exclusive of solution gas in the production from a uniformly-permeable section at 100 percent displacement efficiency.

Oil Ahead of Gas

The oil p initially in place is defined by

$$p = 7758f(1 - I)/b \qquad (16)$$

where f is porosity, I is interstitial water, b is the volume factor for oil and p is in barrels per acre-foot.

Cumulative oil recovery from a reservoir may be expressed as follows:

$$C = 0.01p\,[U_oV_o + mV_b] \qquad (17)$$

where

C = barrels of oil

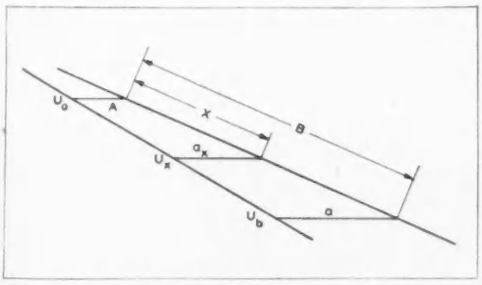
V_o = acre-feet of pay above an M contour

V_b = acre-feet of pay within a B-M region

m = displacement factor, percent of in place oil.

The barrels of oil defined by equation (17) is the volume of oil displaced ahead of gas and is called the breakthrough oil recovery.

The sketch in Figure 4-4 illustrates a procedure for estimating the breakthrough oil recovery for pressure maintenance. Gas is injected through wells located near the crest of a pay interval consisting of several beds. Oil-producing wells are located and completed updip from water or above an impermeable bed which is underlain by water. In-



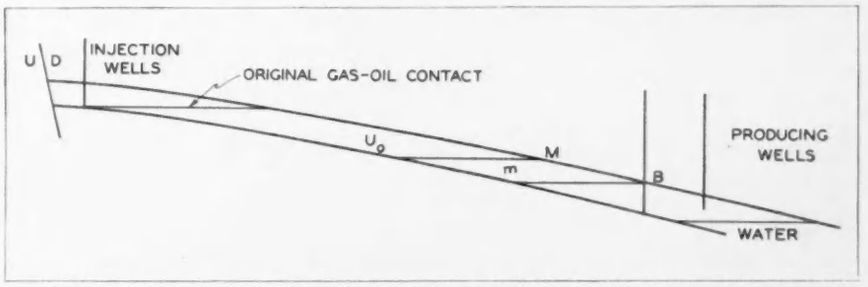


FIGURE 4-3 (left). Illustrating the derivation of the displacement factor m for a B-M region. FIGURE 4-4 (right). Illustrating a procedure for estimating the breakthrough oil recovery from a sandstone pay interval by pressure maintenance with gas; the gas-oil interface advanced from the original elevation of the gas-oil contact to the level shown by the B contour; the M contour is updip from B; oil recovery is U_o from the acre-feet above M and m from the acre-feet within B-M at the time of breakthrough into structurally-highest producing wells.

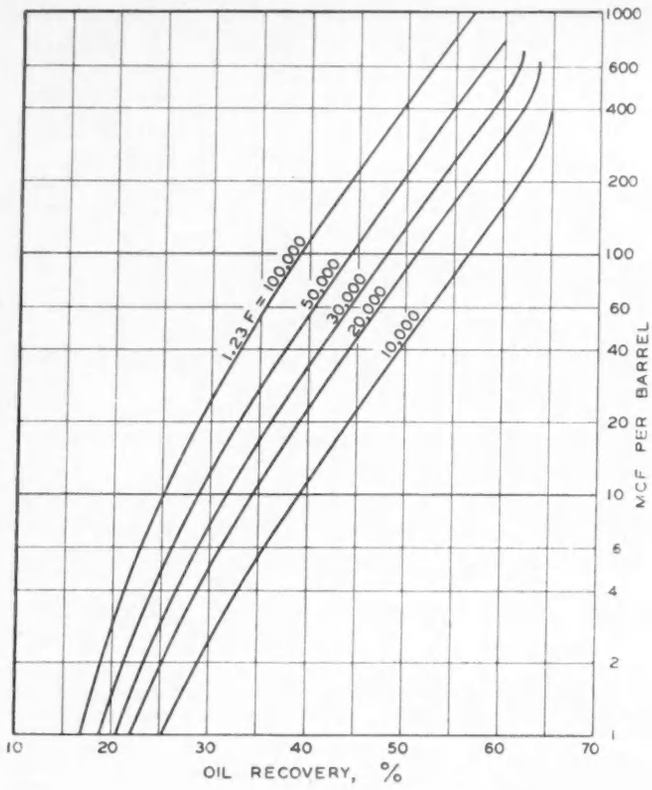


FIGURE 4-5. Per-bed oil recovery in the vicinity of producing wells vs. pressure-fluid factor F and producing gas-oil ratio exclusive of solution gas.

jected gas advances the gas-oil interface or B contour. At the time of breakthrough, the average position of a gas-oil interface is at some level such as B. The average position of the maximum recovery section is at some level such as M. The dip distance between B and M varies primarily with the distribution of permeability and secondarily with the distribution of oil pay, convergence, within a B-M region.

The distribution of permeability as between beds controls the position of an M contour. Thus, a limestone reservoir may have cavernous porosity, solution channels, of high permeability localized in a comparatively thin stratigraphic section. At the time of breakthrough via the bed of high permeability, the M contour may have advanced some nominal distance such as 10 percent of the distance advanced by the B contour via the solution channels. Breakthrough oil recovery is small for all reservoirs having an extremely wide range of permeability ratios. But with control of per-bed producing rate, breakthrough oil recovery from such limestone reservoirs would approach that for sandstone reservoirs. The following discussion is limited to sandstone reservoirs but it may be applied to limestone reservoirs in which per-bed producing rate is controlled.

Let unity equal the acre-feet invaded by gas. The acre-feet of pay between M and the updip oil productive limit is V_o expressed as a fraction of the invaded acre-feet. Oil recovery from V_o is V_o percent of in place oil. The acre-feet within a B-M region is $(1 - V_o)$. Oil recovery from a B-M region is m percent of in place oil provided gas is not produced. The breakthrough oil recovery in percent of in place oil within the invaded acre-feet is defined by

$$C = V_o(U_o - m) + m \qquad (18)$$

where m is given by equation (13).

Displacement Efficiency and B-M Distance

The average dip distance between a B contour and its M contour is influenced significantly by per-bed permeability ratios. On the basis of uniform permeability, about 100 volumes of gas measured at reservoir conditions would recover all the displaceable oil from a particular section. The corresponding dip distance between B and M contours would be 200 to 300 feet for the usual viscosity ratios and aside from convergence. With convergence, the distance would be 200-300 times convergence where the latter may range from 0.4 to 1.0 except in the immediate vicinity of injection wells. These distances are relative to a unit displacement efficiency, that is, a given volume of gas achieves the maximum recovery from all points in an M section. Gas does not migrate via some particular portion of the section without displacing oil.

On the other hand, the permeability of beds varies along strike and field experience indicates that three to five volumes of gas are required for sandstone reservoirs in order to do the work that could be done by one volume in a uniformly-permeable bed. Displacement efficiency is only 20 to 30 percent. Seventy to 80 percent of the gas forced into a particular section usually passes through via the more permeable portions without displacing oil. In view of which, an average B-M distance equal to 1000C feet is used for the purposes of this work. Thus

$$\text{B-M} = 1000C \qquad (19)$$

where C is the convergence between two levels 1000 feet apart aside from abrupt structural and stratigraphic changes.

In a strictly linear sandstone bed C equals unity and M is about 1000 feet updip from B. The position of M in a strictly radial bed is defined[2] by

$$M = 1000\left[(1 + B^2)^{\frac{1}{2}} - 1\right] \qquad (20)$$

The increase in oil recovery from the region in the vicinity of producing wells advances the section of maximum recovery from its position at breakthrough

• CONTINUED ON PAGE 153

TABLE 4-1
Computation of oil recovery for a radial reservoir.

Thousand Feet, B									
0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Acre-Feet, ah, Percent									
1.0	4.0	9.0	16	25	36	49	64	81	100
Thousand Feet, M									
0.118	0.414	0.803	1.236	1.693	2.162	2.640	3.123	3.610	4.100
Depleted, V_o, Percent									
0.56	0.68	2.58	6.11	11.46	18.70	27.88	39.01	52.13	67.24
Convergence, C, Percent									
38.2	58.6	69.7	76.4	80.7	83.8	86.0	87.7	89.0	90.0
Displacement, m, Percent									
31.87	33.56	34.49	35.04	35.40	35.65	35.84	35.98	36.07	36.18
(ah—V_o), Percent									
0.44	3.32	6.42	9.89	13.54	17.30	21.12	24.99	28.87	32.76
0.62V_o, Percent									
0.35	0.42	1.60	3.79	7.11	11.59	17.29	24.19	32.32	41.69
(ah—V_o)m, Percent									
0.14	1.11	2.21	3.47	4.79	6.17	7.57	8.70	10.41	11.85
Cumulative Oil, Percent									
0.49	1.53	3.81	7.26	11.90	17.76	24.86	32.89	42.73	53.54

Viscosity ratio = 64; oil recovery from V_o is 62 percent.

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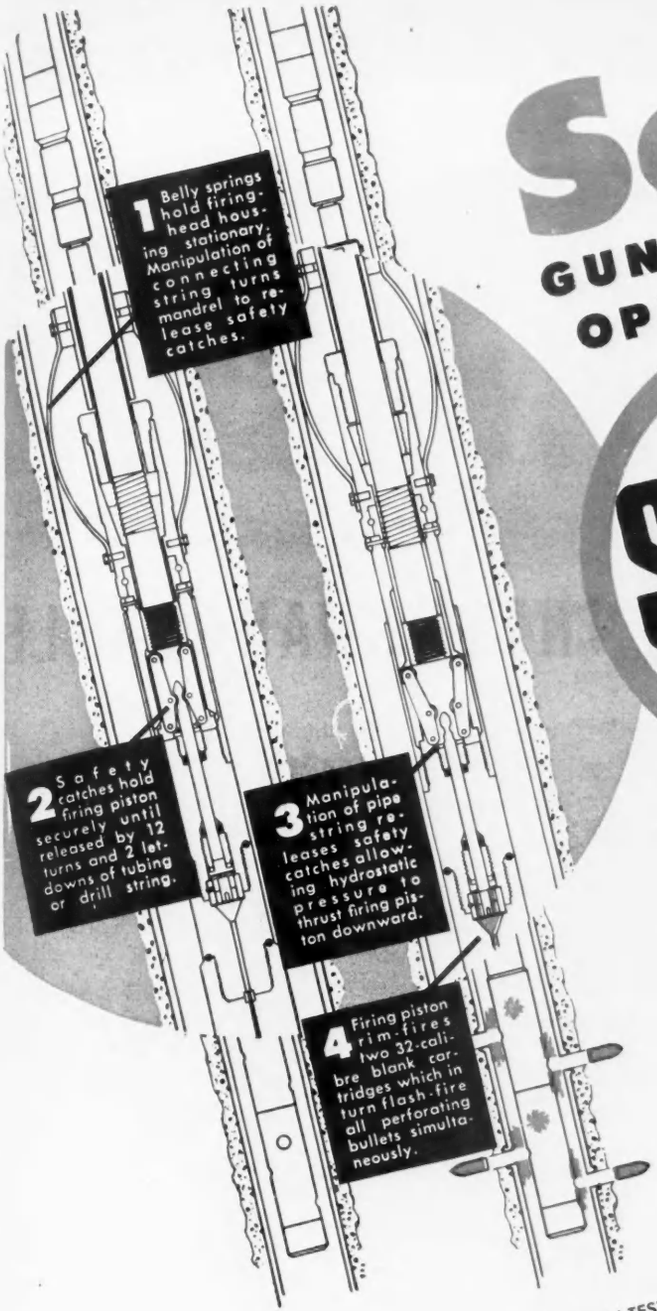
1 Belly springs hold firing-head housing stationary. Manipulation of connecting string turns mandrel to release safety catches.
2 Safety catches hold firing piston securely until released by 12 turns and 2 letdowns of tubing or drill string.
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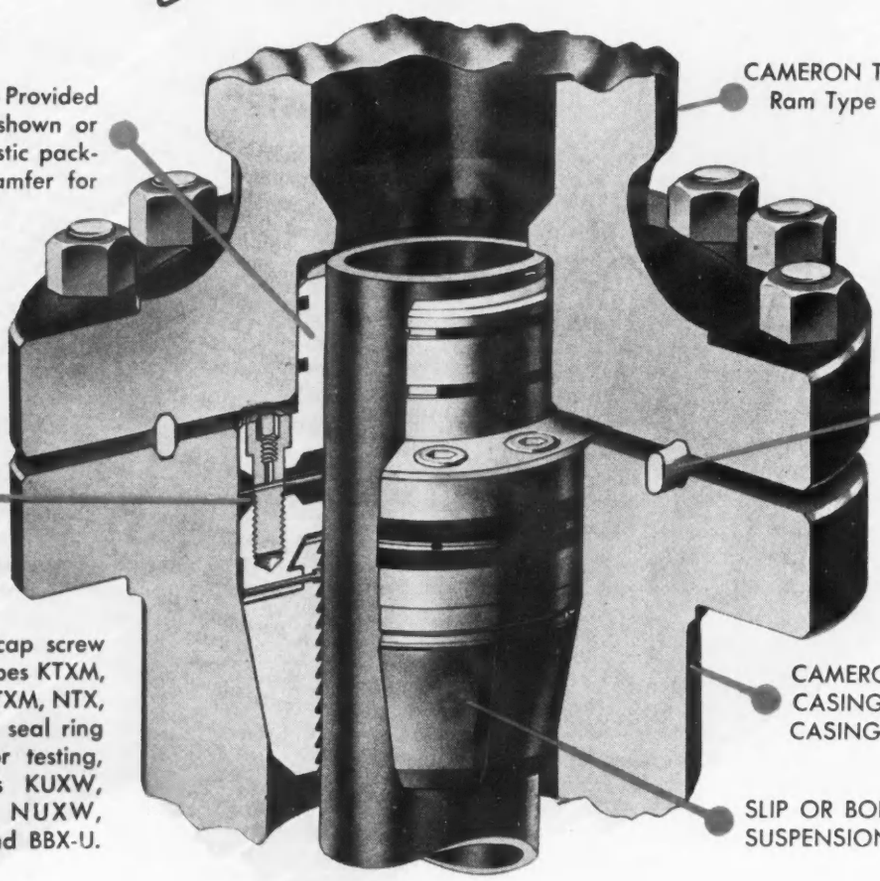

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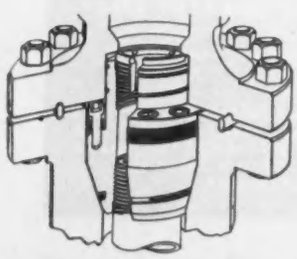

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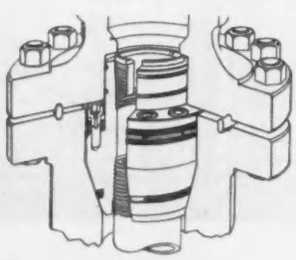

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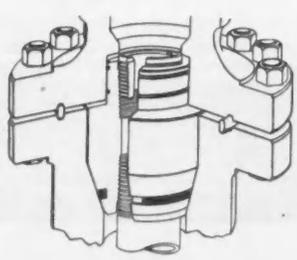

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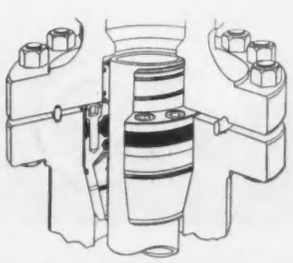

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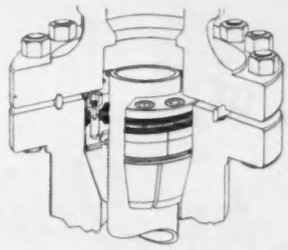

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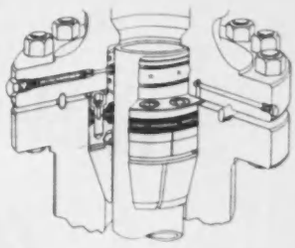

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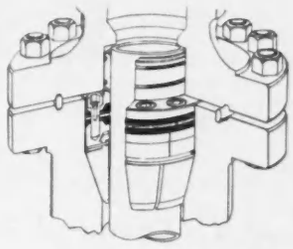

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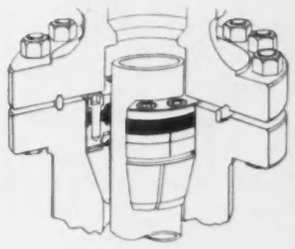

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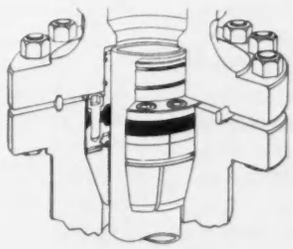

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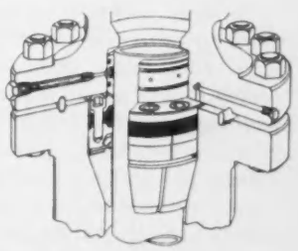

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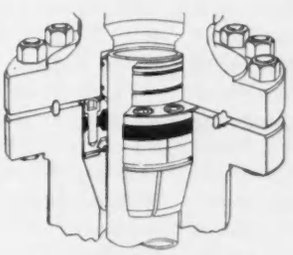

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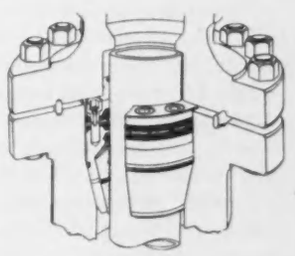

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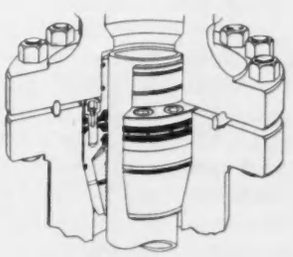

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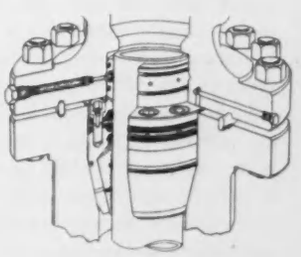

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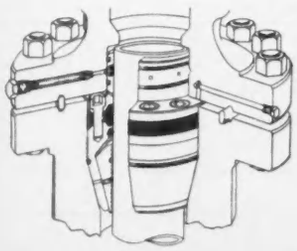

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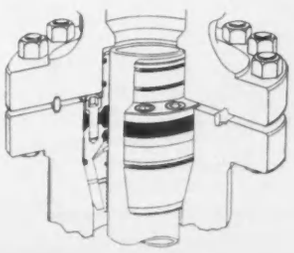

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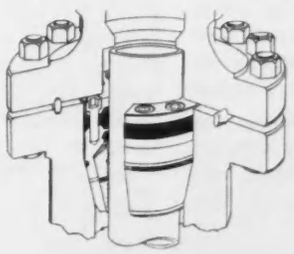

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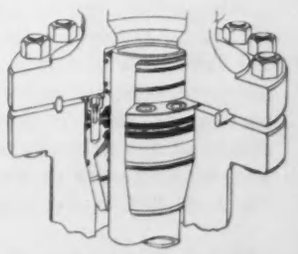

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Problems of Water Injection in Wells and Corrective Methods

By L. C. CASE
Gulf Oil Corporation

Part 1 Chemical Problems in Water-Flooding

THE AUTHOR defines and segregates some of the problems which are common to many water-injection projects, suggesting methods whereby various combinations of factors may be utilized to obtain greatly augmented water intake. Case histories illustrate the efficacy of measures.

THE association of oil and water in rocks deep within the earth is a source of many interesting and difficult problems. Incomplete drainage of oil from these rock formations makes water-flooding desirable and the "water wet" condition of most oil formations provides a physical basis for its application. Less fortunate is the fact that large volumes of salt water often must be produced in order to obtain relatively small volumes of oil, resulting in disposal problems.

Water injection in deep wells, as now practiced in the oil industry, in some instances serves the dual purpose of waste brine disposal and repressuring of depleted oil formations. The problems which are encountered in fresh water and brine injection are widely variable in nature, depending on existing conditions in different oil fields which govern quality and quantity of water to be handled, the nature of the underground formations into which the water is injected and the presence or absence of commercially valuable oil in the injected formation. In some fields, for example those of central and western Kansas, the injection is practiced almost solely for the purpose of waste brine disposal. This is due to the fact that brine is produced in extremely large quantities and the limestone producing formation as a general rule does not respond to repressuring. A few exceptions are known where reservoir pressure is helped somewhat by injecting water into the lower part of the Arbuckle lime, or producing zone. On the other hand, channeling and serious damage to producing wells may result from injecting water into the upper portion of the Arbuckle. This was proved at one well where a dye solution was injected with waste brine in the upper 30 feet of the Arbuckle. In this case the dye showed up in less than ten days at a nearby pumping well. The result of this field test is considered sufficient reason for the rather common practice of casing off the upper 30 to 50 feet of Arbuckle zone in injection wells of the western Kansas area.

In oil fields of other areas the small amounts of brine produced with the oil may offer little if any disposal problem and larger volumes of waste brine may even be desirable. If it is found that the producing formation is suited to water flooding, it may become necessary to supplement the waste brine supply with treated fresh water or brine from wells drilled for this purpose alone.

The problems of water injection are mainly engineering ones of installation and operation, which are primarily the concern of petroleum engineers. However, the chemist must be consulted quite often in order to correct or obviate serious difficulties. Standard engineering practice neither anticipates nor solves all of the difficulties which may develop in the practice of water injection. For example, the mingling of fresh waters and brines of varying salinity and character may result in the formation of troublesome plugging deposits in gathering equipment, well injection tubing, and perhaps even in the underground formation which receives the water or brine. The results of water mingling and injection will ordinarily be readily apparent to a competent chemist from consideration of the chemistry of the waters to be injected, together with data on the recipient formation and its enclosed brine. Published reference has been made to the types of deposits which may be expected as a result of mingling various waters[1] and examples are also given in the literature of many such deposits which are commonly encountered.[2]

In general, salt water has been found more satisfactory than fresh water for flooding relatively "tight" sandstone producing formations which contain clay minerals or similar materials. Fresh

TABLE 1
Analyses of Plugging Deposits

	Deposit from Injection Well, Okla. Project No. 4. Fresh Water Partially Treated Unfiltered	Deposit from Salt Water Tank, Okla. Project No. 6 Unfiltered
	Percent	Percent
Al_2O_3	2.5	trace
$CaCO_3$	55.6	32.2
$MgCO_3$	37.0	trace
$CaSO_4$	1.1	0.3
$Fe_2O_3.3H_2O$	3.4	57.9
Oil	0.0	8.8
Water-soluble Salts	0.0	0.4
Inert	.1	0.2
Total	99.7	99.8

TABLE 2

Chemical Nature of Flood Water and Formation Brine Oklahoma Projects 3, 4 and 5

		Raw Flood Water	Treated Flood Water Unfiltered	Lime-treated Filtered	Formation Brine
mgm. per l.	Na	128	....	....	41,153
	Ca	143	70	94	5,038
	Mg	41	2	30	2,468
	SO_4	54	....	....	60
	Cl	375	....	....	79,345
	HCO_3	271	nil	210	290
	CO_3	nil	27	nil	nil
	OH	nil	13	nil	nil
	Fe	20	nil	nil	60
	Turbidity	5	25	0	.....
Total Solids, @ 105° C.		1,037	1,163	1,153	129,617
	pH	7.2	10.2	7.7	6.8
	pH_s @ 75° F.	6.9	7.7	7.7	.....
	Langelier Index	0.3	2.5	0	.....

TABLE 3

Brine Analyses—Oklahoma Project No. 6

		Tonkawa Sand Brine	Wilcox Sand Brine (Waste Brine)
mgm./l.	Na	67,315	66,706
	Ca	16,952	16,908
	Mg	2,316	2,332
	SO_4	330	328
	Cl	140,260	139,300
	HCO_3	50	32
Total Solids		227,223	225,606
	Fe	33	31
	pH	6.6	6.7
	Specific Gravity @ 60° F.	1.157	1.156
	Primary Salinity	73.86	73.70
	Secondary Salinity	26.12	26.28
	Primary Alkalinity	.00	.00
	Secondary Alkalinity	.02	.02
		100.00%	100.00%

water has a greater tendency to hydrate or swell these impurities with resultant permanent damage to permeability. Although the phenomenon of base exchange and its effects on the state of dispersion in soil colloids had been known for many years, the earliest published direct reference to the swelling of clay in sandstones, and resultant damage to permeability, was not made until 1933.[3]

Deposits which tend to collect and obstruct water flow in injection systems usually may be removed by various chemical or physical methods, depending on the nature and volume of the deposits. However, preventive treatment has been proven more economical than remedial measures. It follows that, in the planning and construction of any water injection system, all possible attendant conditions should be given thorough study in advance of actual water injection. A number of examples will be given of chemical problems which have been encountered in water-flooding practice and solved by laboratory investigation. It should be noted that these illustrations do not include field or laboratory trial of wetting agents, which have been treated adequately elsewhere.[4] Also, the discussion does not include chemical phases of corrosion problems which are sometimes present in water flooding, since these corrosion problems did not appear at any of the flooding projects which are described.

Problems in Water Flooding

It is now common practice to precede water flooding, even on a pilot plant scale, with a large number of investigations concerning the nature of the oil reservoir. The scope and detail of these studies allow fairly accurate predictions to be made as to the amount of flood water required, the rate of advance of the water flood and the amount of oil to be recovered by the flooding process over a given period. A few outstanding examples of unsuccessful water floods have been observed where non-uniform permeability or discontinuity in sand lenses indicated much too cursory investigation prior to the flooding process. Obviously then, intensive preliminary studies on the reservoir are of primary importance. Failure of one flood project, due to discontinuous or lensing sand bodies, after drilling input wells and installing expensive pressure equipment, showed conclusively that more detailed geological and engineering data should have been obtained. In this instance, the data would have proven decidedly economical even though the drilling of one or more additional core holes would have been required.

In the search for more and better reservoir information, it seems that some apparently unimportant details are often overlooked. Many occurrences of severe increase in input pressure and even plugged wells are reported where reservoir conditions were favorable but no consideration was given to the nature of the injection water, the formation brine, and the possible effect of the injection water in the oil formation. Conditions responsible for these occurrences then become a serious matter, to be presented to the chemist for immediate and complete explanation. It is indeed fortunate that these errors of omission in preparation for water flood usually do not lead to operating difficulties of such magnitude as loss of injection well or its equipment. Nevertheless, some of the remedial measures found necessary have proven costly and entirely worthy of more consideration than they have received.

Sludge accumulation from gravity line and injection tubing. Composition is essentially calcium carbonate, iron sulfide, sulfur, oil, water.

Because of the fact that the chemist's initial introduction to these problems may be that of examination of plugging material and prescribing for its removal and prevention, it would be well to consider first the nature of some of the deposits which have caused plugging of injection well equipment. It is a rather common occurrence for operating problems to be presented for solution to technicians in backwards fashion because men in operations seldom have a basis for anticipating such things as chemical precipitates. When initial waterflood tests are being planned for field tests, the chemist ordinarily is not furnished samples of flood water, formation water nor data on the attendant physical conditions to secure a prediction of what might happen and to determine methods for preventing trouble. Rather, he is proffered samples of solid material subsequently removed from injection tubing or well bore and requested to determine cause and cure. The general constitution of two such deposits is shown in Table 1. In the absence of any information concerning the injection water at Oklahoma Project 4, the analysis of the chalk-like substance removed from the bottom of the injection well is patently without significance. The single fact that a partially treated, unfiltered water was being used for injection at this project quite strongly indicated that satisfactory explanation would be found in additional data which are shown later.

The deposit from the salt water tank at Oklahoma Project 6 was interpreted as possibly due to contact of the waste brine with air which allowed release of CO_2 and precipitation of calcium car-

TABLE 4

Chemical Nature of Flood Water and Formation Brines Oklahoma Project No. 1

	1. Lease Water System (Flood Water)	2. Average Bartlesville Brine	3. Average Arbuckle Brine	4. Scale (from Mixing 2 and 3)	
				Oil	1.25%
				$CaCO_3$	trace
				$BaSO_4$	96.15%
				$Fe_2O_3.3H_2O$	2.05%
				SiO_2	0.33%
Na	446	51,750	58,300		
Ca	183	10,800	13,900		
mgm. Mg	34	1,800	2,180		
per Ba	0	150	0		
l. SO_4	23	0	190		
Cl	934	104,800	120,800		
HCO_3	275	40	50		
Turbidity	0–2	.....	.....		
Total	1,895	169,340	195,420		99.78%

TABLE 5

Relative Effect of Salt and Fresh Water on Permeability of Pennsylvanian Sand, Kentucky

Plug No.	1.	2.	3.	4.	5.	6.
Permeability, millidarcys	107	209	73	100	130	185
Permeability to oil, ml/min.	1	3.5	1.75	1.5	1.5	3.5
Permeability to oil after flooding with salt water, ml/min	1	3.2	1.0	0.75	0.75	1.0
Permeability, millidarcys	107	174	71	100	125	164
Permeability to oil after flooding with fresh water, ml./min.	0.75	0.5	0.5	0.6	0.2	0.3
Permeability, millidarcys	98	156	50	88	99	147

bonate. Also, the presence of so much hydrated iron oxide indicated oxidation and precipitation of the iron which is originally in solution in the ferrous state. This information was available prior to injection of waste brine at Project 6 and, consequently, a partially closed system with filter has prevented plugging in the injection well. The material removed by the filter has a composition quite similar to that shown by the analysis of sludge from the bottom of the salt water tank.

Some of the chemical relationships of the waters at Oklahoma Water-flood Projects 3, 4 and 5 are shown in Table 2. The untreated well water was found to be only slightly unstable. However, it was objectionable from the standpoint of turbidity, which was almost entirely due to iron. This water was receiving partial softening with lime and soda ash, cold process, to render it suitable for domestic use and cooling water. Filters were not used and the treated water had only about 12 hours theoretical time in the sedimentation tanks. As a result, the water going to the injection well was carrying a very high turbidity which naturally would be filtered out at the sand face near bottom of the well. Consideration of the nature of the formation brine shows that the partially treated water would also tend to cause plugging of the oil formation by the reaction of residual lime and soda ash with the brine.

In summary, the situation demanded partial treatment for iron removal, with some softening. Yet the treated water must be stable and carrying no residual treating chemicals which might react with components of the formation brine. The Langelier index[5] provides a means of precipitation control in cases of this kind. More recent references[6,7,8] have illustrated methods of using this type of water-treatment calculation in a readily-understandable manner. The pH at calcium carbonate saturation of the lime-treated water was found to be 7.7 and treatment was adjusted accordingly at the central treating plant handling 6000 barrels daily. Pressure filters were installed in the lines to the injection wells which have operated subsequently without trouble. The filters are cleaned by backwashing at periods determined by the rate of water input. The material removed by the filters is quite similar to the material taken from the injection well prior to adjustment of treatment and sediment removal. This experience illustrates a simple, although effective, application of chemical equilibrium methods in water conditioning. These methods have recently been expanded in considerable detail by Caldwell,[9] who has simplified calculations greatly by plotting the data in chart form.

The characteristics of waste brine and formation brine at Oklahoma Project 6 are shown by the analyses in Table 3. The Tonkawa sand body is Pennsylvanian in geologic age, while the Wilcox sand body is of Ordovician age. It seems indeed remarkable that the brines of these two zones, of different geologic eras and separated by approximately 1500 feet of intervening sedimentary rock, should be so closely similar in nature. It is readily apparent that the brine from either zone could be used quite successfully for flooding the other zone, provided of course that suspended sediment were first removed. If it were practical to remove all oil from the brine in the complete absence of air, then the waste Wilcox brine would be entirely without sediment. However, very slight contact with air produces turbidity due to precipitated iron and a lesser amount of calcium carbonate. Complete iron removal would require considerable aeration and time for coagulation. In most cases of iron removed from brines of this nature, it becomes expedient to complete the iron removal by the addition of a small amount of lime and coagulant following aeration. The use of a sand filter at Oklahoma Project 6 accomplishes the dual purpose of removing traces of oil, as well as that portion of the iron and chalk which has precipitated.

The material removed by the filter is similar to the deposit which was taken from the bottom of the salt water tank at Project 6 except that the oil content is considerably higher. The presence of a comparatively high oil content in the sediment requires cleaning of the filter by back-washing twice daily. The injection well at Project 6 takes all available waste brine under gravity flow and trouble due to plugging is not anticipated.

Water analyses and related phenomena at Oklahoma Project 1 are shown in Table 4. It will be noted that the water from the lease water system has slight and variable turbidity, as determined at the laboratory. Since these tests were made on samples which had stood some time, it is logical to assume that the water from the closed system enters the injection well at near zero turbidity. This lease system water would doubtless be suitable for flooding the Arbuckle zone. The fact that it has been used successfully for flooding the Bartlesville zone proves conclusively that the pres-

TABLE 6

Water Flood Projects

PROJECT	Formation Flooded	Water Injected	Water Input Barrels Daily	Water Input Barrels Cumulative	Type of System	Filtered, Material Removed	Injection Pressure, Psi.	Well Clean-out Methods
Oklahoma 1	Bartlesville sand	Fresh	135	139,884	Closed	No	Gravity	None
Oklahoma 2	Prue sand	Fresh	193	189,700	Closed	No	280—450	None
Oklahoma 3	Glenn sand	Fresh	74	206,700	Semi-closed	Yes, chalk*	260—450	Bail, Acid
Oklahoma 4	Glenn sand	Fresh	180	365,600	Semi-closed	Yes, chalk*	140—200	Bail, acid
Oklahoma 5	Glenn sand	Fresh	330	222,000	Semi-closed	Yes, chalk*	0—70	None
Oklahoma 6	Tonkawa sand	Brine	500	131,400	Semi-closed	Yes, $CaCO_3$, Fe oxide, oil	Gravity	None
Illinois 1	McClosky lime	Brine	400—500	20,000	Closed†	No	Gravity	None

* Mainly $CaCO_3$ from partial lime-soda ash treatment.
† Dump flood—casing perforated in Cypress sand and water allowed to gravitate into McClosky. Reservoir filling up.

Deposit removed from injection well which received unfiltered, partially treated water. Composed of calcium carbonate, magnesium carbonate, iron oxide and wind-blown silt.

ence of a small amount of sulfate will not produce sufficient barium sulfate on mingling with the Bartlesville brine to cause plugging. It is not considered feasible to water flood the Arbuckle limestone zone of this oil field. However, many thousands of barrels of brine are produced daily with oil from the Arbuckle pay zone. Injection of this waste brine into the Bartlesville sand would be extremely desirable from the standpoint of waste brine disposal as well as that of repressuring. Nevertheless, the relatively high amount of sulfate in the Arbuckle brine and the comparable amount of barium in the Bartlesville formation brine show that the Arbuckle brine should not be injected into the Bartlesville zone. In all instances where these brines are allowed to mingle, a deposit is formed very similar in constitution to the scale analysis shown in Tale 4. Evidently, the Bartlesville brine contains a small amount of strontium also, since some scales resulting from mixing these rines have shown as much as 4 percent $SrSO_4$.

The sandstone strata which have been referred to in discussion of several water-flood projects are known to be relatively "clean" sands of high and rather uniform porosity and permeability. Such zones usually have the ability to receive large volumes of either salt or fresh water under low injection pressures. Probably, the sand purity and uniformity are much more important than other factors. "Dirty" sands, or those containing clays or shales, have been observed to be adversely affected by fresh water. This phenomenon was probably first noted in the case of "drowned" wells which were ruined, or nearly so, by fresh water entry. Many investigators have illustrated the effect by laboratory experiments and as a result it is now rather common practice to find the relative effects of salt and fresh water by laboratory "flood pot" tests on cores taken from wells during well completion operations. These laboratory tests sometimes show quite definitely that fresh water should not be allowed to come in contact with certain sandstone oil zones. Tale 5 lists tests on sand cores which strongly indicate that injection of fresh water would be decidedly dangerous. After drilling these plugs they were dried, extracted with naphtha, and dried again. Permeability was then determined with air. Flow of oil was then measured before and after flooding the plugs with salt water. The plugs were again extracted and their permeability to air found. The effect of flooding with fresh water was found by the same procedure. It will be noted that flooding the plugs with fresh water reduces the permeability to oil more than flooding with salt water. It is shown also that fresh water causes appreciable plugging which prevents the sand from being restored to its original state—a phenomenon which is not exhibited by the salt water.

Table 6 contains some general information on a number of water-flood projects. In view of the previous discussion, these data are of considerable interest and importance in evaluating the success or failure of water-flood projects. From the standpoint of water injection rather than oil recovery, all of these projects are considered successful. Using these data, supplemented with details on physical nature of sand body and chemical characteristics of formation and injection water, it is possible to check the few rather simple rules by which any successful water-flood should be operated.

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(TO BE CONCLUDED NEXT MONTH)

Oil Production By Gas and Flooding

■ CONTINUED FROM PAGE 146

to a position M feet from the wells which is not likely to be less than

$$M = 1000C\,\frac{U_o - E}{U_o - U_b} \qquad (21)$$

where U_o and U_b are the maximum and breakthrough recoveries and E is the oil recovery at economic limit from the pay in the immediate vicinity of producing wells. Solution of equation (21) requires correction for displacement efficiency in advancing an M contour after breakthrough of gas into producing wells.

The displacement efficiency in the vicinity of producing wells equals unity at the time of breakthrough. After breakthrough the displacement efficiency decreases from unity to about 25 percent. Thus as E increases from U_b to U_o displacement efficiency decreases. Values of E are given by equation (4) in terms of gas-oil ratios at unit displacement efficiency.

The average breakthrough recovery U_b is about 12 percent and the average maximum, about 62 percent. On the assumption that the produced gas-oil ratio R increases linearly as E increases from 12 to 62, we have

$$R = \frac{14 + 300E}{50}\,R_o \qquad (22)$$

At breakthrough E equals 0.12 and R equals R_o. At $E = 0.62$, R equals $4R_o$ where R_o is defined by equation (4) for any value of E equal to C. The curves in Figure 4-5 are solutions of equation (22).

Ultimate Oil Recovery

The gas-oil ratio at economic limit defines E the probable oil recovery in the vicinity of producing wells. This value substituted in equation (21) gives the approximate position of an M contour. The latter, in turn, defines the partially depleted region $(1 - V_o)$. The oil recovery from $(1 - V_o)$ is $(U_o + E)/2$. The ultimate recovery U from the acre-feet invaded by gas is given by

$$U = U_o V_o + (1 - V_o)(U_o + E)/2 \qquad (23)$$

where U is in percent of in place oil within the acre-feet updip from producing wells. Note, however, that if V_o equals zero, an M contour is not developed and the oil displaced from the updip productive limit is less than U_o. Table 4-1 illustrates a solution of equation (23) for producing wells located 5000 feet from the center of a radial reservoir.

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[1] Jones, P. J., "Petroleum Production," Vol. I, Reinhold Publishing Corp., New York, 1946.

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PRODUCTION HINTS

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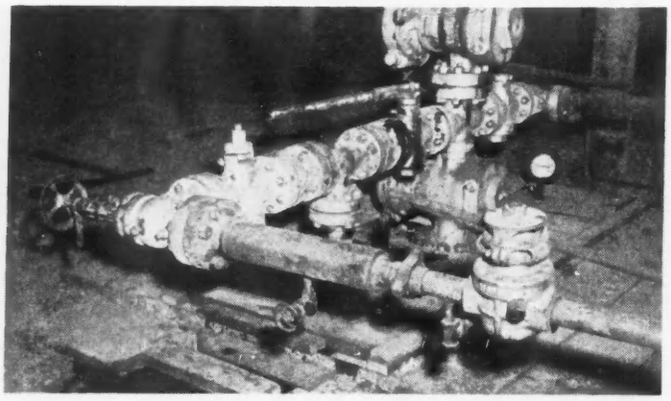
HOW TO—Reduce Abrasion of Lead Lines on Flowing Wells

On certain flowing wells, the abrasive and destructive action upon lead lines immediately downstream from the flow bean sometimes is quite severe, necessitating frequent replacements. One company has eliminated or considerably reduced much of this trouble by installing



in the lead line a chamber of four-inch heavy pipe, the unit being welded and assembled as shown. As well fluid enters the chamber from the downstream side of the bean, its velocity is reduced considerably. Any abrasive action which does occur is confined principally to the replaceable chamber. A small barstock bleeder valve is placed on the under side of the chamber. The chamber, which can be made up in standard lengths and sizes in the shop, is removed as a unit merely by unscrewing a two-inch union and removing a bolted flange.

HOW TO—Construct Simplified Field-Made Crude Oil Heater

Handling thick crude emulsions can be facilitated in the field through installation of a field-made heater, such as that illustrated. The heater shown is placed in the flow stream between the well and the separator. Production flowing through the heater comes from pumping wells.

The heater itself is simply a 14-foot section of ten-inch casing which has been sealed at both ends to house a corresponding section of eight-inch casing. The oil flows through the annulus between the two sections of pipe. This annulus is welded closed at the fire-box end, while the opposite end is equipped with an expansion joint which compensates for the differences in expasion between the inner and outer pipe. The eight-inch pipe continues through the expansion joint and through a right-angle bend, extending to a point about ten feet from ground level. A flat cover serves as a shield over the stack to prevent entry of rain.

A sheet-metal firebox was constructed around the gas burner to protect it from wind and rain. The burner is the ordinary shop-made type, the lip of which extends approximately an inch or two into the heater. A thermometer mounted into the ten-inch section measures the temperature of the oil. A temperature of about 70° F. is maintained through manual control.

A swing joint is provided at the exhaust of the heater in order that the elevated flow line leading to the separators can expand and contract without resultant damage to connections. To facilitate flow in extremely cold weather, one-half-inch gas line was welded to the bull plug at the swing joint. By jetting gas into the flow line, the heavy crude could be kept moving.

Cleaning facilities for the heater were also provided. Since it is necessary to drain the elevated flow line to empty the heater, a drain line was installed near the center of the heater as shown. This line drains off into a sump where the oil can be picked up again for reheating. A collar and bull plug near the firebox make it possible to drain out heavy asphaltic material which may adhere to the inside heating pipe. This unit has been in operation for several years, and, according to its builders and users, is doing a satisfactory job.

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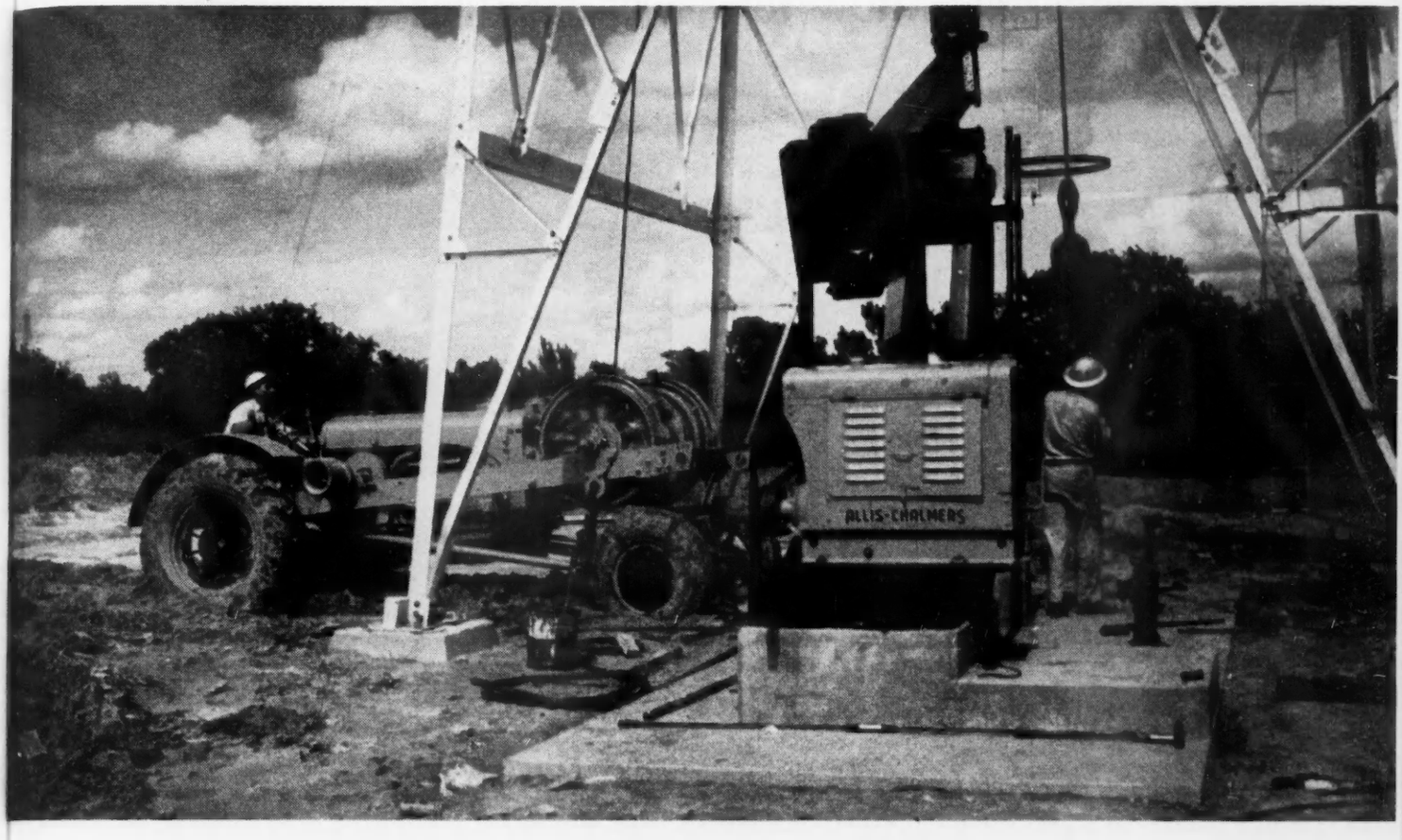

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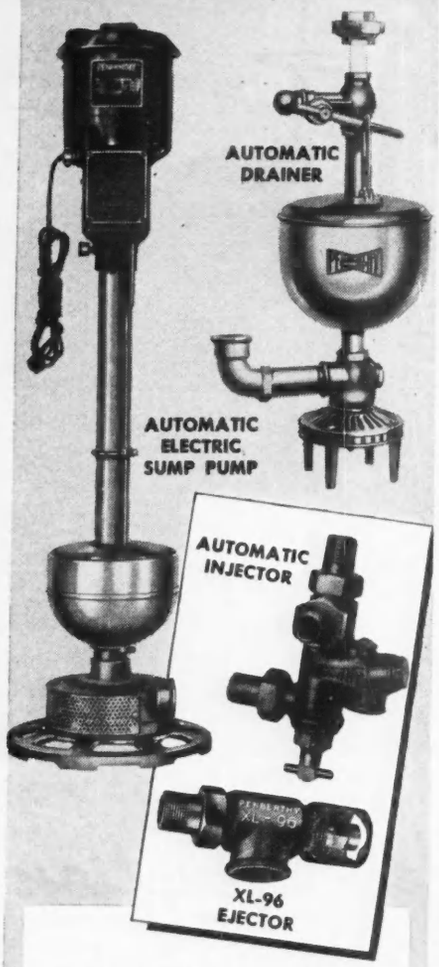

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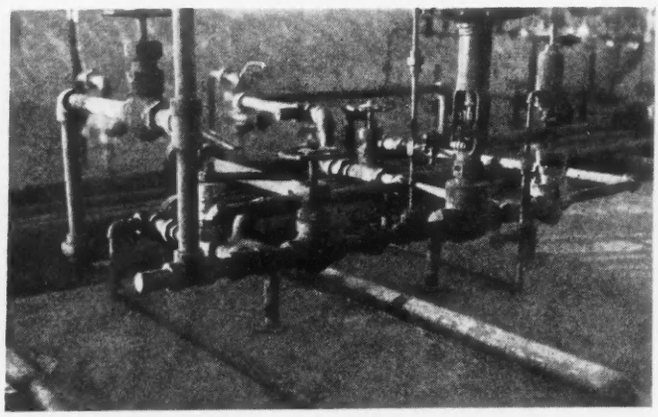
HOW TO—Build Adjustable Line Supports



The danger of leakage or outright failure occurring in high pressure lines or assemblies not adequately supported is particularly acute when such lines are subjected to constant and damaging vibrations. Generally, on a more or less permanent installation, it is not too satisfactory to use wooden blocking as supports, and in addition, it is difficult with blocks to obtain the exact height desired for each support point. One company, confronted with the need of such supports on high-pressure lead lines and pressure regulating assemblies, designed and built up a number of inexpensive adjustable screw jacks. Made principally of salvaged materials, the typical jack consists of a short length of heavy tubing, to the bottom of which is welded a square base plate, and to the top of which is welded a heavy nut, the latter being of a size ranging from three-fourths- to one-inch size. A threaded stud of similar size, to the top of which is welded a short, cutout section of pipe to serve as the yoke into which the supported line is cradled, then is screwed down into the nut. A jam nut may be run on to the stem also, if desired. Any length jack body or stud may be employed, such dimensions being dependent upon the size, type of line, and distance above ground it is to be supported.

The high pressure piping assembly illustrated is typical of the type of use to which the jack is adaptable. After the unit is spotted beneath the pipe fitting, a pipe wrench may be used to turn the

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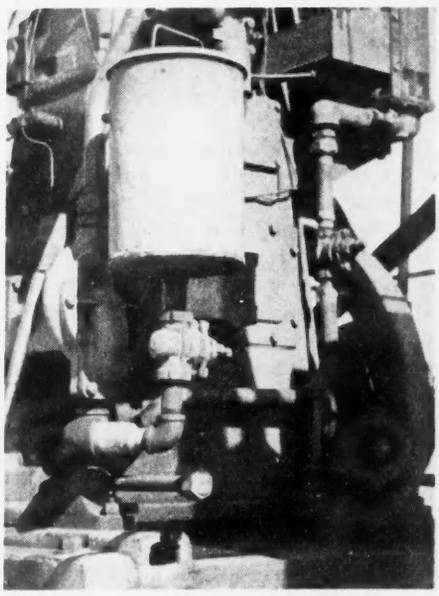
HOW TO—

Make Safe Fill Device

To eliminate hazards involved in filling the radiator of a vertical engine which might be in use on a pumping lease it has been found advantageous to rig a device which permits the operator to fill the radiator while standing on the floor. The radiator fill pipe of these



engines is located about six feet from the floor level, necessitating the operator climbing above the floor and running the risk of slipping on icy steps or guard rails. On the suction line to the engine circulating pump a nipple, ell and swedge nipple are placed, forming a takeoff for locating the filling tank. Next an ell is placed on the swedge nipple. A short nipple, quick closing gate valve, short nipple and the filling tank are then mounted on the ell.

The radiator flow line is then brought to the top of the fill tank. To fill the radiator the pumper needs only to pour fluid in the fill tank, open the gate valve and the pump suction will pick up the fluid. When the radiator is full the fluid will start flowing back through the overflow line to the fill tank. Antifreeze tests may also be made from the fill tank.

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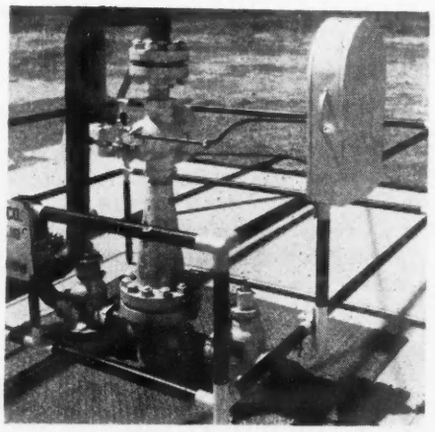
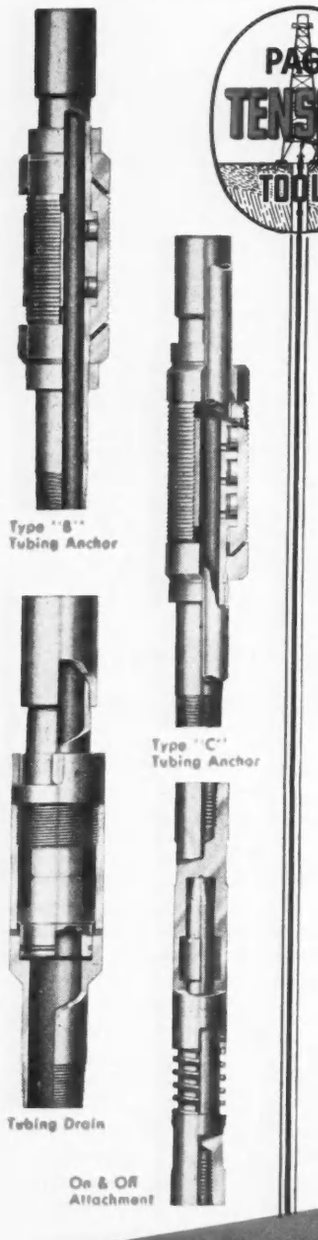
HOW TO—Simplify Installation of Well Recording Meters

Instead of attempting to fabricate special bases or racks on which to mount recording meters at each well, one company operating in the Rocky Mountain area has devised a simple, inexpensive support that can be constructed and set up in a very short while on any well equipped with the common type of guard rail enclosure. Attached to the bottom of the meter case is a single length of two-inch pipe, to the back side of which have been welded two pairs of angle iron clips. These clips are positioned to match the two horizontal rails of the guard surrounding the wellhead. Given the dimensions and distance between these rails, the company welder



easily can make up the support in the shop or in the field. A single bolt run through matching holes in each of the clips secures the unit to the guard rail. If such guard rails are made up to a standard size, with dimensions and size of pipe used identical in each installation, the simple meter mounts can be made up in advance, greatly facilitating the interchange of meters and installation of new meters on newly completed wells.



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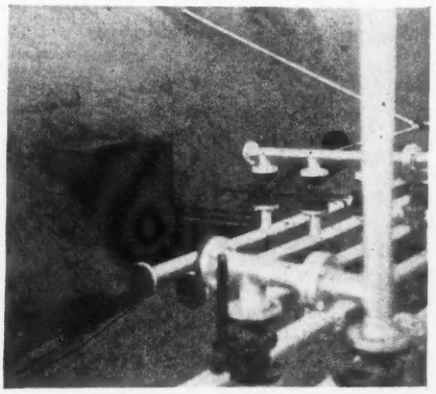
HOW TO—

Install Blowdown Box

Neatness around the separator and tank farm is desirable not only for the sake of good housekeeping itself, but for the reduced fire hazard and increased



safety of the men who must work in the area.

One major oil company makes it a practice to install beside high pressure separators a large rectangular steel blowdown chamber into which blowdown lines are connected. Built from material recovered from salvaged steel tanks, the box is entirely enclosed except for a drain line on the bottom which allows oil and water to drain into a common waste line, and a hinged cover which can be opened for inspection purposes. The chamber is inexpensive to build, takes up little space at the site of the battery, and is easily moved.

HOW TO—

Actuate Pump Controls

The delay and inconvenience of starting and shutting down an electric pump which transfers tank bottom drainings from the sump to the water purifying and treating plant can be eliminated with an automatic device, most of which is standard and readily obtained from supply stores. The type of float, however, which starts and stops the motor is frequently made by mechanics in the machine shop, many of which operate with greater efficiency than others.

One type which is trouble-free and operates to the satisfaction of the employes is made by forming a rectangular box, approximately 12 x 14 x 4 inches, from stainless steel sheets, securely welded air tight. Across the top of this float is placed a cross-bar having a threaded coupling in the center for attaching a one-half-inch pipe long enough to extend upward to a latch. This latch is connected to the electric switch which opens and closes as the float rises and falls on the surface of the liquid.

Across the corner of the sump, two supports are bolted which carry three pipe guides, one in the center for the half-inch switch actuating rod, or pipe, and the two on opposite sides as guides for the float which is connected loosely by holes in each end of the cross-bar to prevent twisting caused by the wind and eddy currents in the liquids.

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HOW TO—Pump Water Well With Oil Unit

One company drills the water well for the lease near the first well to go on the pump so it can be operated by the same unit. After the tubing and rods are run into the water well, a beam is fastened to the sampson post of the pumping unit with a hinge as shown, so that it can swing up and down.

The front end of the small beam is fitted with a bridle and clamp for the polish rod. A short chain is fastened to the walking beam of the large unit and the other end is looped around the small walking beam. A hook and eye arrangement just above the small beam allows the well to be hooked off when sufficient water has been pumped. This is accomplished by standing a plank under the beam and slipping the hook out of the eye. When it is necessary to pump more water, the hook is replaced and the plank removed.

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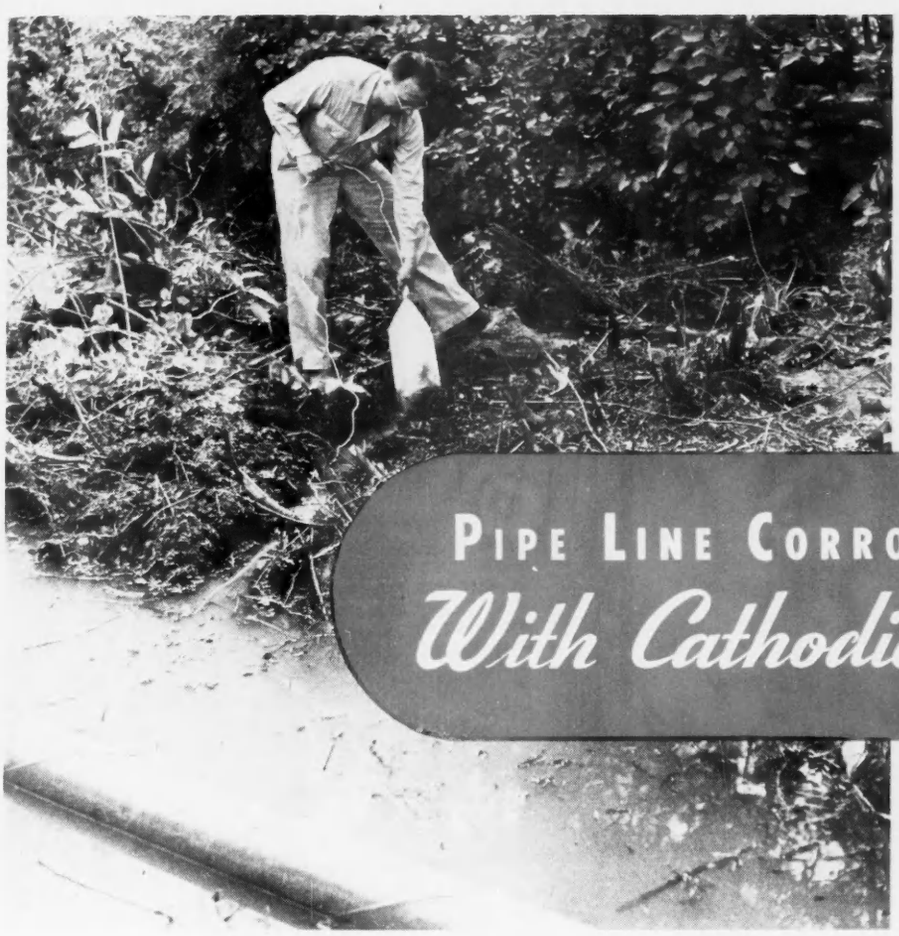


PIPE LINE CORROSION CONTROL
With Cathodic Protection

Installing pre-packed magnesium anodes along pipe line right-of-way.

By K. D. WAHLQUIST
Manager, Southwest Division,
Electro Rust-Proofing Corporation,
Dallas

THE AUTHOR recommends practices which not only isolate corrosive currents from distribution systems, but which are also effective in preventing corrosion loss to station manifolds and pipe networks, as well as the service systems at company camp installations.

THE cost of corrosion of pipe lines and other buried structures to American industry is best evidenced by the extensive research study continuously under way to combat these losses.

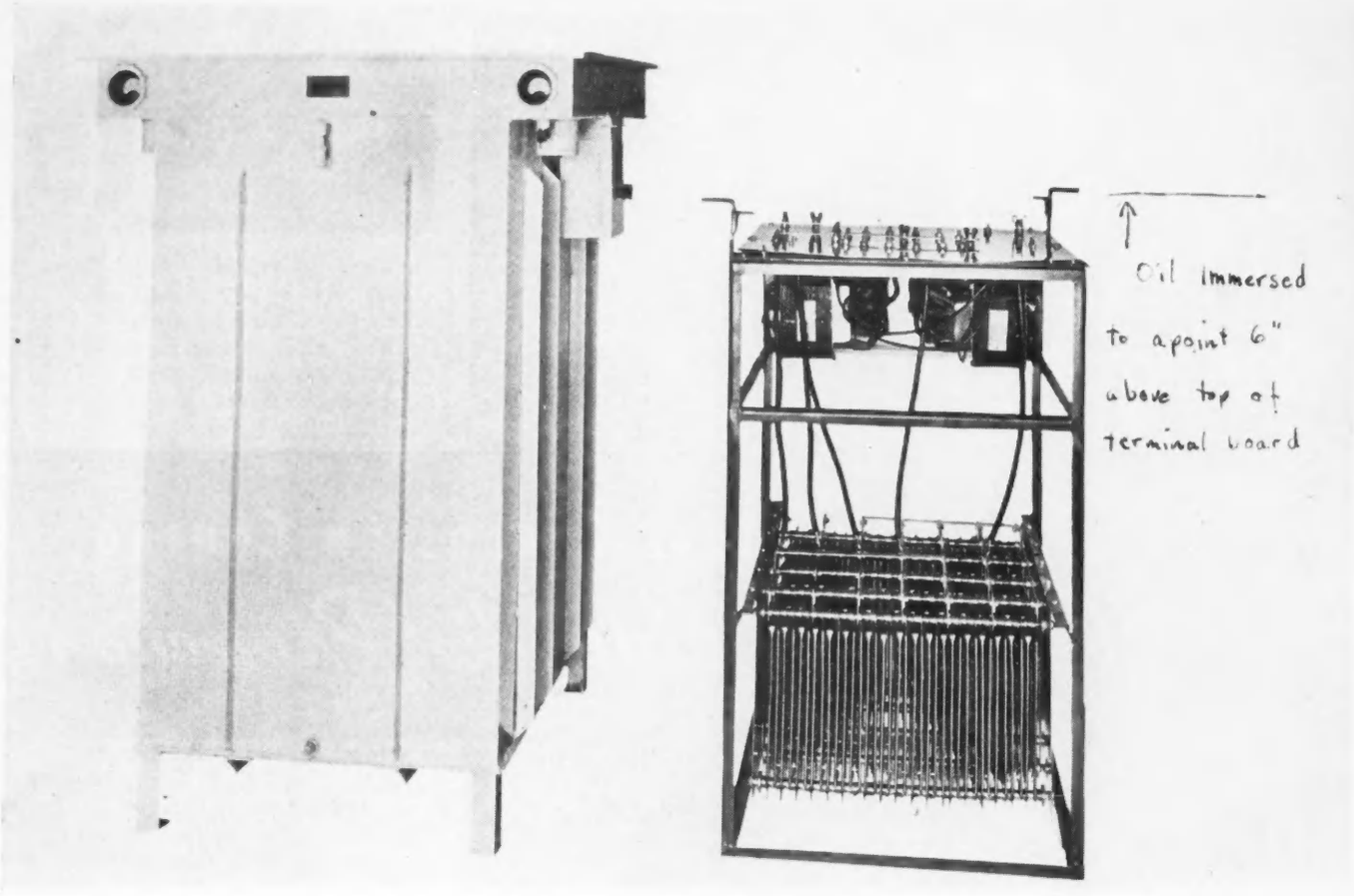
To prevent the loss of metal and structure failure, resulting from corrosion, industry has resorted to insulating barriers—paint, cement, asphaltic and bituminous compounds or other coatings on the surfaces of the exposed metal. These coating alone are completely effective only when perfectly applied and maintained, and pipe lines under several feet of cover are, of course, inaccessible for maintenance or replacement of the coatings. Any pin holes, flaws or breaks in the barrier film resulting from back-filling, soil stress or normal deterioration may concentrate the normal corrosion activity of a large area at these "holidays," thus leading to rapid penetration of the metal at these exposed areas.

Mechanism of Corrosion

The mechanism of corrosion has been established as electro-chemical in nature with reactions occurring between metal surfaces and chemicals in the soil or water in contact with metal surfaces. Areas of differing electrical potential to ground occur over the metallic surface, acting as local anodes and cathodes, while the soil or water in contact with the metal surface acts as an electrolyte. As a result of this, current flows from the anodic area through the soil and back to the cathodic areas and metallic ions are released in the solution at the anode, resulting in rust and pitting. The possibility of stopping the escape of metallic ions by electrically preventing the flow of current from the metal was first demonstrated in 1824 by Sir Humphrey Davy.[1] This method, now known as cathodic protection, has been developed until it is today recognized as one of the most satisfactory and economical methods of preventing the corrosion of steel in contact with water or soil, especially when used in conjunction with paint or other coatings.

Correlating Committee

The simplicity and direct effectiveness of cathodic protection in preventing corrosion losses and reducing maintenance costs has resulted in wide acceptance and use of this method in prolonging the life of buried and submerged metal structures. A Correlating Committee[2] on Cathodic Protection has been established by 11 nation-wide organizations. These include the Association of American Railroads, American Gas Association, American Petroleum Institute, American Public Works Association,



Oil-immersed cathodic protection rectifier.

American Water Works Association, Edison Electrical Institute, International Municipal Signal Association, U. S. Independent Telephone Association, Bell Telephone Companies, Western Union Telegraph Company, and National Association of Corrosion Engineers. The basic objective of this committee is to promote better understanding of cathodic protection and to obtain the needed cooperation among operators of all types of corroding structures in its beneficial application.

Its Application

Cathodic protection is applied by burying an auxiliary anode as a substitute for the local anodes on the metal surface to be protected. The auxiliary anode may be energized by an external source of direct current such as rectifiers, motor generators or wind chargers, or may furnish its own current as an anode composed of a metal higher in the electro-motive series than the metal to be protected. In either case the electrical energy is supplied by the auxiliary anodes at sufficient electrical pressure to prevent the flow of current in the local cells on the protected metal surface. With the flow of current stopped at the local anodes on the protected structure, the escape of metallic ions is transferred to the auxiliary anodes, which may be replaced easily and economically as they are expended to protect the structure.

Cathodic protection is used to police the holidays which develop in various coatings to pipe lines in contact with the soil. Although the oil-drying type of paint is usually quite thin and permeable to moisture penetration, it is fairly effective in reducing current density requirements for protection. The coal tar enamel and asphaltic type coatings, because of their imperviousness to moisture, high electrical resistance, and resistance to the hydroxl ion concentration developed at the metal surfaces, are effective in reducing the current requirements. The same reduction in current density requirements for steel submerged in aqueous solutions through the use of efficient coatings has been shown by L. P. Sudrabin.[3] The combination of applied coatings and cathodic protection should be considered in establishing the most satisfactory protection procedure on new structures. In the case of existing pipe lines, which were not coated when installed, economic considerations may indicate the use of cathodic protection alone.

Sufficient direct current must be supplied to lower the potential to ground of the protected structure, and where considerable current is required, a rectifier or other source of impressed current is used. This is done by connecting insulated wires from the power source positively to the ground bed anodes and negatively to the pipe line. Ground bed anodes may be of scrap metal, such as pipe, rail or of graphite. Where lower values of current are required, galvanic anodes of magnesium, aluminum or zinc may be buried in the ground and connected to the pipe by insulated lead wires. Prepared chemical backfills are usually provided around the galvanic anode to reduce anode to soil resistance, as the difference in closed circuit potential between the galvanic anodes and the steel structure does not exceed one volt. The source of current and type of anodes to be used is determined from conditions such as soil resistance, total current requirements and availability of power lines to selected ground bed sites. The recent development of more efficient magnesium alloys for galvanic anode use and the availability of these alloys in shapes and forms suitable for this use represents a major contribution to the industry. The low electro-chem-

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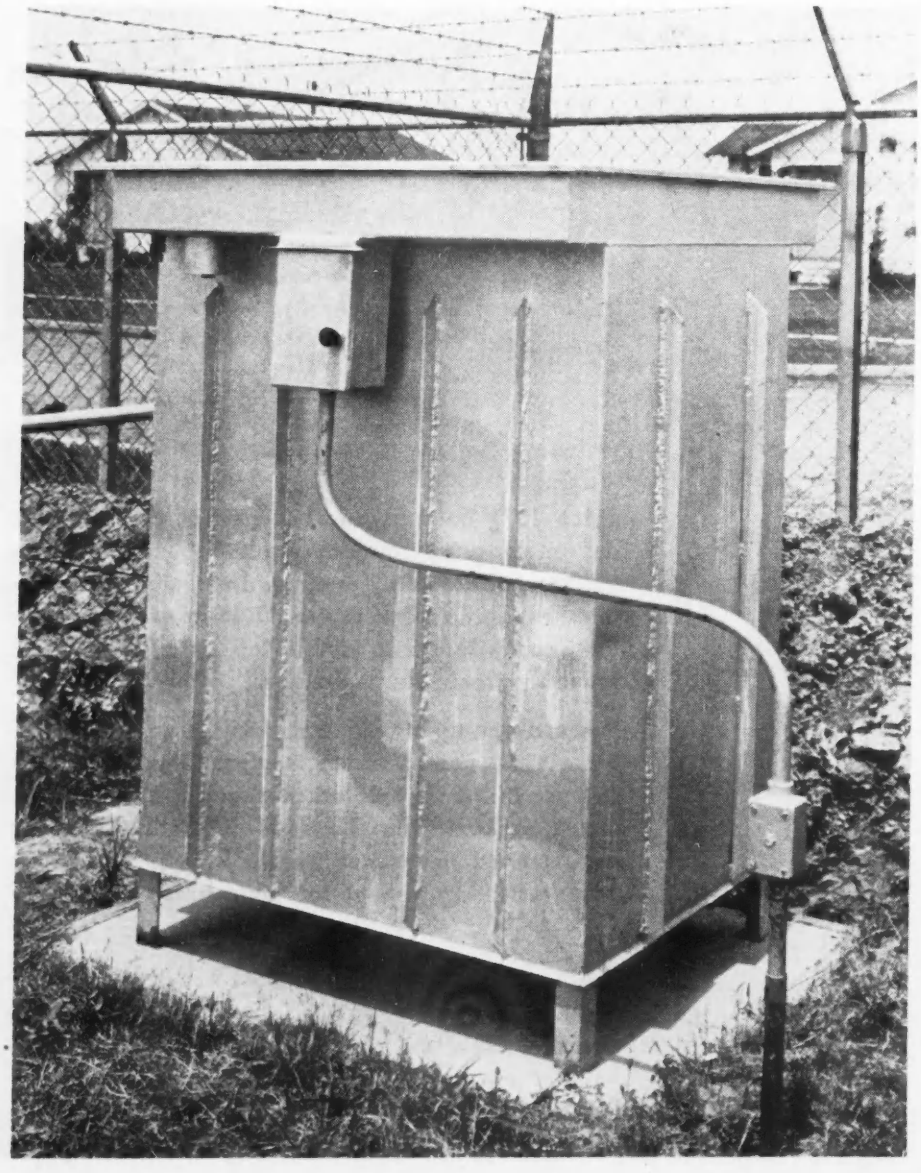
ical equivalent, high driving voltage and freedom from polarization effects, of magnesium anodes furnishes a dependable source of power at low cost for many installations.

Where cathodic protection is applied to a pipe line in an area where other metal structures are present, some of the current may enter foreign structures. If this occurs, the current must be drained back to the power source by drainage bonds between the foreign structure and the protected structure. Resistance bonds limit the current drain and therefore the current pickup on the foreign structure. Where this possibility exists, the owners of the other structures in the area should be consulted and a cooperative study made of the problem. Very often cathodic protection of neighboring structures is undertaken as a joint project usually resulting in a more economical installation for all structures involved.

To design an effective cathodic protection installation, and determine its cost, it is necessary to consider all factors involved. Considerable data are obtained by electrical tests with instruments designed for that purpose and requiring special knowledge for their operation. Further, to interpret the data obtained from the tests requires specialized knowledge and experience. The investigation, engineering and supervisory costs are usually a small part of the total cost of protective measures and ordinarily are less than the savings effected by the employment of inexperienced personnel. The total cost will vary due to many factors such as pipe size, effectiveness of coating, soil resistance and availability of electrical current. Pipe to soil potential readings, current measurements and soil resistance readings are usually taken at frequent intervals on the structure. Data obtained, correlated with leak records, if available, and a corrosion profile map are used in the determination of the amount of current to protect the pipe line along with anode locations. Experience accumulated by the corrosion engineer in installing previous applications is most valuable.

There are consulting and service organizations available to provide survey, design, material and installation on cathodic protection systems. The economies to be realized through the use of the experience and installation procedures obtained from many applications in the field is indicated by the increasing use of these services by many of the major oil and gas pipe line owners who previously have been designing and installing their own applications. In this way it has been found possible to put more miles of pipe line under protection each year than would be possible with the limited technical, supervisory and labor force available for this work in most pipe line companies.



Oil-immersed rectifier installation for cathodic protection of pipe line.

Scope of Applications

The scope of cathodic protection applications is being extended to oil, gas and water transmission pipe lines, gas and water distribution systems, oil storage tank bottoms, open top condensers, lead-sheathed cables, storage tanks and treatment equipment in the water and sewage industry, and to steel pilings, docks, ship bottoms and other structures in contact with sea water. A particularly interesting application of cathodic protection was made in 1947 to a 30-mile, six-inch section of gas transmission line in Michigan. Due to immediate requirements for gas service and critical shortage of pipe, it was necessary to install thin-wall invasion pipe with a wall thickness of 0.101 inch. It was obvious that the thin-wall pipe provided no corrosion allowance, and it was imperative that the line be fully protected against corrosion. The line was coated and wrapped, but with a coating which provided only fair dielectric strength so that the current required was somewhat higher than had a more resistant coating been applied.

A survey has been made to determine the corroding areas and the current requirements for protection, and 17 pounds of packaged magnesium anodes were installed at 1000-foot intervals along the pipe line except in urban districts and at river crossings. A total of 231 anodes was installed with an average spacing of 690 feet. The current output per anode averaged 0.040 ampere which indicates

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The pictures show a few details of a Latex operation—laying a 20-inch pipe between Beaumont and Houston for the Texas Pipeline Company.

Said an old-timer on pipeline construction: " 'Caterpillar' Diesels have everything it takes for putting pipe in fast, right and profitably. For clearing right of way to powering ditchers, to moving material, to stabbing, cradling and laying pipe, to backfilling and cleaning up, you can count on these dependable machines staying on the job till it's done—twenty-four hours a day if necessary."

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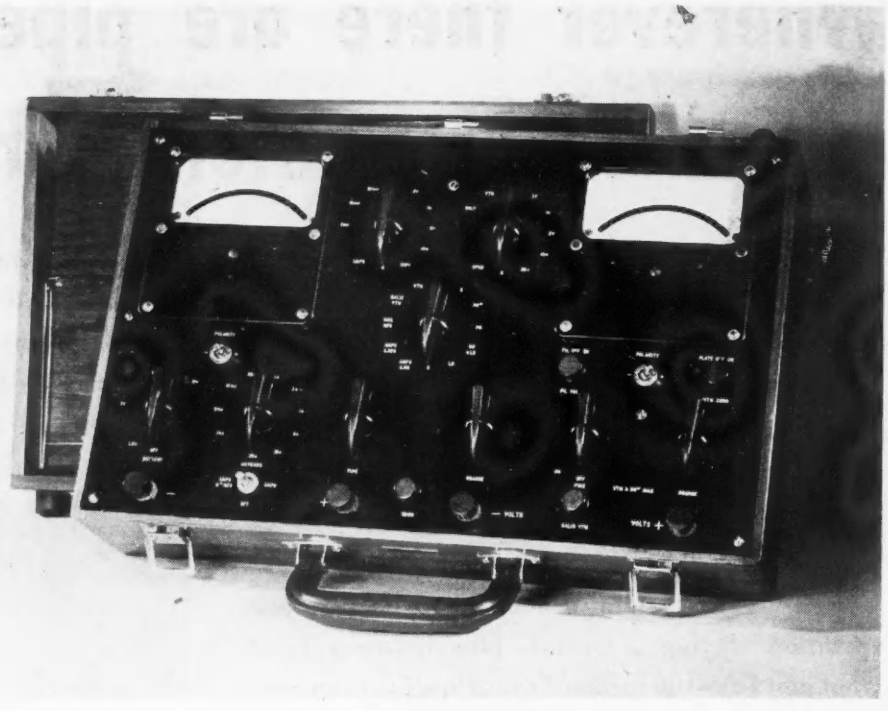
a useful life of 20 years or more for this installation. A total of 9.0 amperes was delivered by the anodes for an average current density of 1/3 milliampere per square foot of coated pipe. The line was electrically isolated at each end and a survey made 90 days after installation showed that the pipe to soil potential throughout this length had been brought up above the accepted protective value of —0.85 volt to a Cu/CuSO_4 reference electrode. Cost of the cathodic protection for this line will average about $11 per mile per year.

Effect of Coatings

As as example of the effect of coatings on over-all costs, a recent application to a six-inch proudcts pipe line, where current requirements were greatly reduced by an efficient coating, cathodic protection was obtained again using packaged magnesium anodes at an indicated cost of approximately $1.66 per mile per year.

The successful application of cathodic protection to the underground piping in an entire municipality was made at Lake Jackson, Texas,[4] in March, 1946. The city of Lake Jackson was built almost overnight to provide housing for workers in nearby war production plants. Sewage and utility piping was laid during 1941 and 1942, and within three years corrosive soil conditions and couples between mains and galvanized service lines resulted in 18 leaks in water service piping being reported in about three months. Pipe to be placed under protection included ¾-inch bare galvanized water service lines, coated and wrapped steel 4- to 6-inch gas mains, and ¾-inch gas service lines with all-welded joints. Because of the bell-and-spigot joint it was assumed that only the joint to which the service line was attached would be affected by cathodic protection. The two systems were electrically connected through the water heaters in each house.



Multi-meter for electrolysis and cathodic protection testing.

Design Factors

Design factors included: (1) average soil resistivity; and (2) area of steel pipe to be protected and current density requirements to protect the unit area of steel in the given environment. Soil resistance measurements made with a Leeds-Northrup Soil Bridge and specially designed electro-prod rod showed a range from 500-2500 ohms/cm^3 in the represented areas of the town. From previous experience in the area, it was estimated that one milliampere per square foot of steel surface would be required for protection.

A pipe to soil potential and current output survey made after the anodes were installed showed that within a week after the job was completed the water and gas service lines in the area of the cathodic installation were under complete protection, and since completion of the work, not one new leak has appeared. The average pipe to soil potentials, as measured at each meter at the time of the preliminary survey in April, 1946, was —0.681 volts and after installation were —0.910 volts, in April, 1946, and —0.861 volts, in May, 1947, with the latter survey made during a long period of excessive dryness. During the short three-month intervals in which leaks occurred, repair costs amounted to almost one-half the cost of the cathodic protection installation. On this basis the cost of cathodic protection will be saved many times during the indicated 7-10 year life, based on average current drain of 90 ma. for the 16 pound anodes installed.

A number of installations have been completed during the past year for complete gas distribution systems in cities and towns in Wisconsin, Iowa, Nebraska and South Dakota where leaks, due to penetration of the distribution piping by corrosion, had resulted in an alarming loss of gas. Installation practices on gas distribution systems include effective isolation at the border stations and at the meters at each service to reduce total current requirements and restrict protection to the gas system. Costs vary due to soil resistance,

About the Author

K. D. WAHLQUIST attended Washburn College at Topeka, Kansas, entered the Army, and upon his discharge in 1918 joined the staff of the division plant engineer for Western Union Telegraph Company, Omaha, Neb., where he spent considerable time on the mitigation of corrosion on underground lead-sheathed cable. He served on electrolysis committees in Omaha, Kansas City, Mo.; Des Moines; Denver, St. Paul, and Duluth, Minn. He was with Dow Chemical Company in field development of magnesium anodes for cathodic protection from October, 1945, to June, 1947. He is now Southwest district manager for Electro Rust - Proofing Corporation with headquarters at Dallas.

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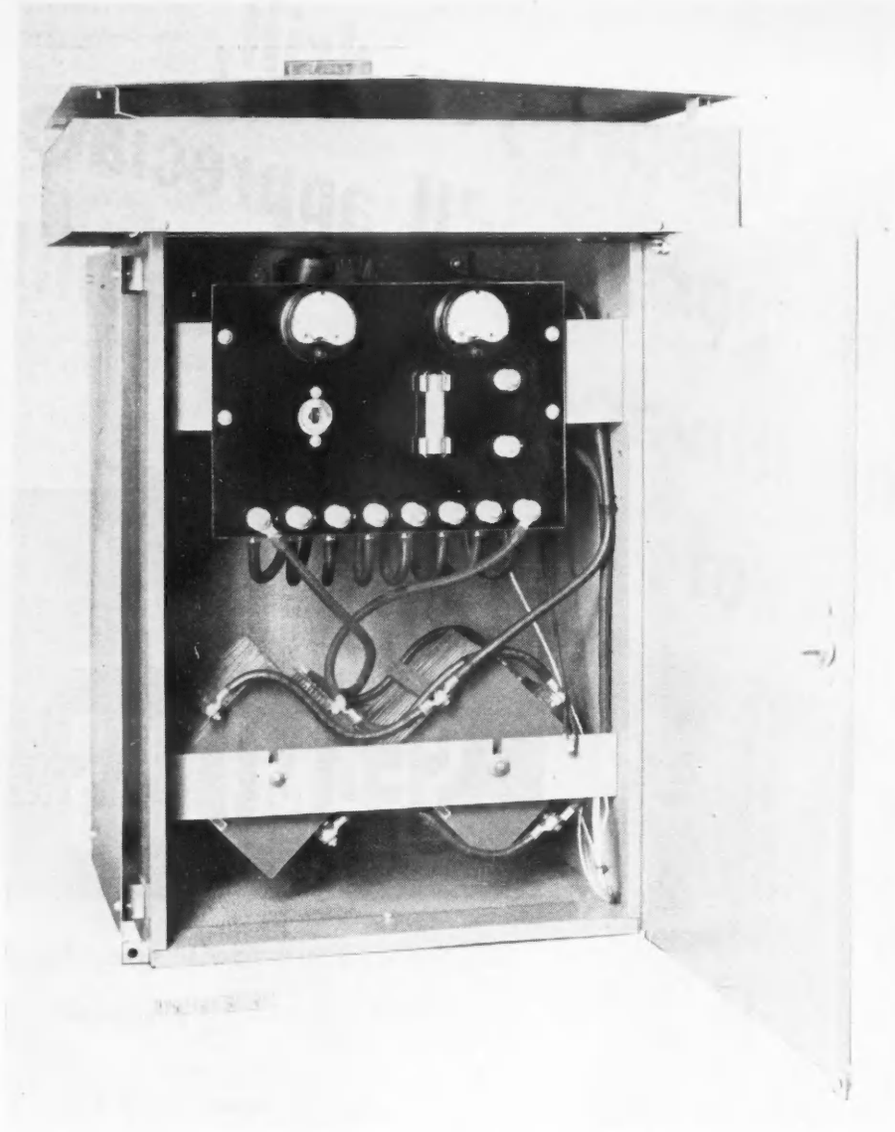

(Courtesy Federal Telephone & Radio Corporation)

Cathodic protection power supply rectifier.

pipe cover, and etc., and range to $1.50 per year per service, for bare pipe.

Summary

Since the first application of cathodic protection more than a century ago, there has been a continuing investigation and improvement of methods, materials and equipment for its application. In recent years the acceptance and the use of the process has been extended to many industries. Mudd[5] stated that, "Corrosion is the prime factor in the cost of line pipe service." Cathodic protection properly applied and efficient coatings, or a combination of both, may be used to reduce the serious dollar cost of corrosion to buried and submerged metals. The successful advancement of this method of corrosion mitigation of buried and submerged structures is proven by its wide acceptance and use. Coating materials for the control of corrosion on buried and submerged structures alone are not sufficient, but used in conjunction with properly engineered and installed cathodic protection are effective and reduce over-all maintenance costs.

For the successful application of cathodic protection, considerable specialized knowledge and experience is required for economical design and installation. In view of the favorable cost and performance data available, management would be well advised to provide funds to engineering and operating departments for placing underground plant equipment under cathodic protection as rapidly as possible.

REFERENCES

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Corrosion Characteristics Of Concrete River Clamps

Examination of pipe lines in the "big inch" class, that is, 20 inches in diameter or larger, indicate that certain precautions must be taken to prevent each clamp from developing a site for augmented corrosion. Unless the wrap is doubled or trebled in the area covered by the clamp, the slight movement of pipe will eventually break the protective coating at the edge of the weight, exposing bare metal in a narrow strip which sometimes extends one-fourth the circumference of the line. Even if the line carries cathodic current, the bare spots may corrode rapidly, and leaks develop although the remainder of the line is still adequately protected.

Instances of edge chafing on clamps has been noted on both high pressure gas trunk lines, using reciprocating compressors, and on oil lines where the throughput is pressured with plunger pumps. The chafing was found more prevalent where the usual river crossing manifold with multiple branches is employed. The sudden change in direction, together with the change in pipe diameter, seemed to set up reflecting areas where the effect of pulsation or—as one engineer postulated—the actual expansion of the pipe diameter under pressure surges, furnished impact or increased pressure at the area between pipe and edge of the clamp.

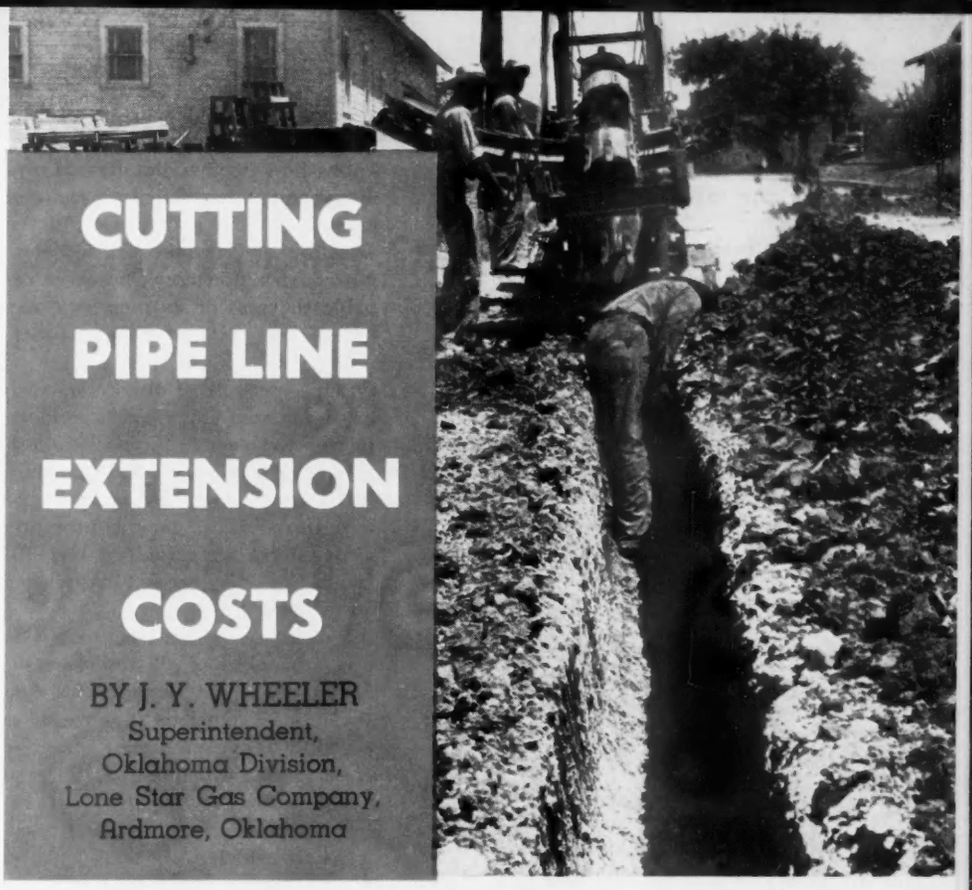
Another failure noted in some concrete clamps is the formation of transverse fractures along the lines of buried reinforcing steel. Water invades the material through pores and if carrying oxygen, soon attacks the steel. The rust thus formed, being confined within the pores of the matrix material, cannot escape, and swells, eventually developing pressures which split the weights and in some instances even break in tension the bolts uniting the clamp halves.

Where the weights are precast and assembled in the ditch around the pipe, coating with melted coal tar or other water sealant even if no other binder be present, is found to shut out the water which otherwise might infiltrate. Use of bolts within countersunk areas on the weights, the recesses to be filled with hot tar after the clamp is bolted into place, also adds to bolt life.

Interlocking clamps, put together on the pipe without bolts, were found intact on examination, but several breaks in the pipe wrap, caused by dragging of the upper half of the weight while being placed, were the causes of incipient corrosion failure.

CUTTING PIPE LINE EXTENSION COSTS

BY J. Y. WHEELER
Superintendent,
Oklahoma Division,
Lone Star Gas Company,
Ardmore, Oklahoma



A SURVEY of preliminaries necessary before beginning construction indicates many ways in which a pipe line company can fail to take every advantage of conditions, and thus involve itself in needless expense. The author lists the more frequent shortcomings, and then provides a catalog of factors which should result in economical and expeditious construction.

Good and appropriate construction equipment is essential for economical construction. Powerful ditch diggers now take the place of manual labor in laying short gas line extensions on many lines.

A FEW years ago the cost of short main extensions was not considered a very important matter in the general operations of a gas distribution system. A few laborers with picks and shovels, a small truck or a team, a welder, and the job was done and the cost was not excessive. That was before World War II and before recent radical adjustments and readjustments in our general attitudes and methods of doing things as well as in our modes of life. That was before laborers were paid time and one-half and double time, and before many other conditions that today confront the pipe line industry.

The laborer is worthy of his hire, and is worth all he gets if his work is properly directed and supervised and he performs it well. If he doesn't earn his wage, it's usually the fault of those charged with the responsibility of planning and directing his work.

Here are some of the things and conditions that have added to the cost of many small projects:

1. Starting before we get ready.
2. Starting in a big hurry with no plan.
3. Commencing a job with too little man or machine power.
4. Starting a job as an afterthought of the foreman and manager when they see a surplus of men on hand in the warehouse. That sort of start is not a planned operation.
5. Waiting until customer pressure for a given extension goads the management into action.
6. Failure to look ahead and plan so that two, three, or four short extensions in the same general neighborhood may be started simultaneously and finished as one operation rather than making several separate jobs out of them.

My company is divided into operating districts, composed of from one to 15 towns. The district office is centrally located and many of the towns are operated from the district office. Where the business of an outside town is sufficient to justify it, we create a sub-district with a sub-district manager in charge. His duties are about the same as those of the district manager except that he also acts as a foreman for his own town and other towns which form a part of the sub-district. Our heavier working equipment is kept at the district office, and is made available for use in all towns in the district. We consider it economical to operate the entire district as a unit, particularly in laying extensions and making replacement of mains. Under this system we can train a crew of men better and give them wider experience and continuous employment. We also find that training a small crew and keeping it busy is more economical than attempting to hire what is termed "extra help." This extra help must be trained and training costs money.

The 40-hour week and higher labor and material costs have made it necessary to plan and execute all operations in an orderly manner if unreasonable ex-

About the Author

J. Y. WHEELER entered the natural gas business after a successful career as a contractor and publisher. He constructed and operated the first natural gas lines and plants in Garvin County, Oklahoma. In 1927 he sold his properties to the Lone Star Gas Company of Texas and has been associated with that company ever since. He is company superintendent in Oklahoma and supervises distribution operations in 28 towns in southern Oklahoma. His wide experience in public utility construction, operation and personnel matters qualifies him as an authority on how to cut pipe line extension building costs.

penses are to be avoided. Many in the industry are doing things just as they were done in the old ten-hour day. In every gas rate case I have appeared in or read of the "reasonableness" of the cost of the plant and all extensions thereto have stood out and have had much bearing on the final adjudication of the rate. A good criterion of whether short extension costs are excessive and unreasonable—even in the light of present conditions—is whether they can be justified. When a company goes into court to justify rates, it cannot stand entirely on the cost of pipe, or what the pipe cost on the ground, or what it may have cost in the ground.

Efficient Methods

Haphazard methods of installation are frequent contributing factors to excessive costs of both long and short extensions. Particularly is this true in short extensions.

During the past few years all of us have been concerned and harassed because of material shortages and material costs. This is something we cannot control. Under these conditions we sometimes find it necessary and profitable to allocate to the more important jobs some of the materials that are obtained from time to time. This piecemeal allocation certainly does not make the cost of a given job any less, even though it seems expedient. Following the expedient course, however, is bad if allowed to become a habit.

The most economical and expeditious construction of main extensions will depend largely upon the following:

1. The installation foreman should be a man of intelligence, experience, ability, and dependability. He must know how to handle men. Local management has failed to exercise enough care in many cases in the selection and training of foremen. No construction crew, however capable the rest of its members, can be efficient without proper supervision.
2. Other members of the crew, such as equipment operators, welders, pipe fitters and other specialists, must know their respective jobs. Misfits and incompetents should be weeded out of the gang as promptly as possible. They foul up the efficiency of the crew. Inefficiency costs money.
3. An extension should be routed to take advantage of all conditions offering the most economical construction. Extensions should always conform to system design and good engineering principles.
4. The position of the proposed extension in streets, alleys and parkways in which it is to be placed must have consideration. Extensions should be so placed as to afford maximum use of all available construction equipment and thereby eliminate unnecessary hand labor.
5. All underground water lines, sanitary sewers, storm sewers, light and telephone cables in the line of construction should be carefully located so that they will not be disrupted by the ditching machine, if one is to be used.
6. A complete detailed sketch or plan of installation should be made for the installation foreman. This sketch should show the property line, sidewalks, or curbs, and all underground and above-ground structures. He should check this sketch on the ground.
7. Good and appropriate construction equipment is absolutely essential for economical construction. Too much or too little equipment and the wrong type of equipment will increase costs. Trucks with winches, booms, and backfill attachments, air compressors with accessory tools, pipe pusher, augers, pipe and cable locators, and proper hand tools are "musts" for efficient and economical construction. Many short extensions require as many pieces of equipment as some bigger jobs especially when pavement or rock is encountered.
8. Before commencing the job the foreman should check and know that all materials required for the project are on hand and should arrange for the delivery of the material to the job at the proper time.
9. Avoid lost motion. Proceed step by step with ditching, welding, testing, painting, laying and backfilling.
10. Service risers should be welded on before the main is placed in the ditch.

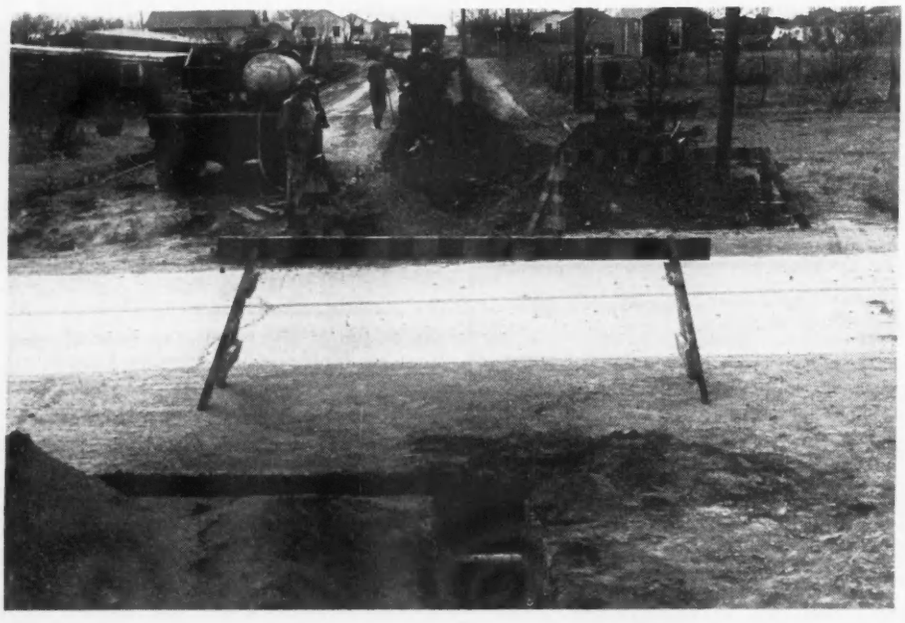
Well-Trained Crews

The value of training men, especially in supervisory capacities, cannot be overemphasized. A good job cannot be done by hiring a crew and simply putting the men to work. They must be trained and after they are trained they must be supervised. Not only that, but they must be properly trained and properly supervised. Employes are human and must be trained and supervised in a human manner. In this particular, many managers and foremen fail.

The careful, efficient foreman will see the job through without personal injury to his men and without exposing the public to hazards that should never be created. The competent, careful foreman knows without being told that accidents and personnel injuries add to costs. He also knows they take their toll in public disfavor when any segment of the public is involved in corporate neglect.

If pavement is cut it must be promptly and properly replaced. If ditches are opened they must be properly filled. New backfills in line of traffic must be tamped to avoid sinking.

The sooner it is realized that any excessive and undue cost of the job has its origin in the local management and in the improper direction of men, the better off we are going to be. If the job is done right, it will come out cheaper, and it will pay dividends in satisfaction and service until it wears out.



Laying short line gas extensions in a southern Oklahoma community. Proper planning permits workers to place lines under public highways without interrupting traffic or creating hazards to motoring public.

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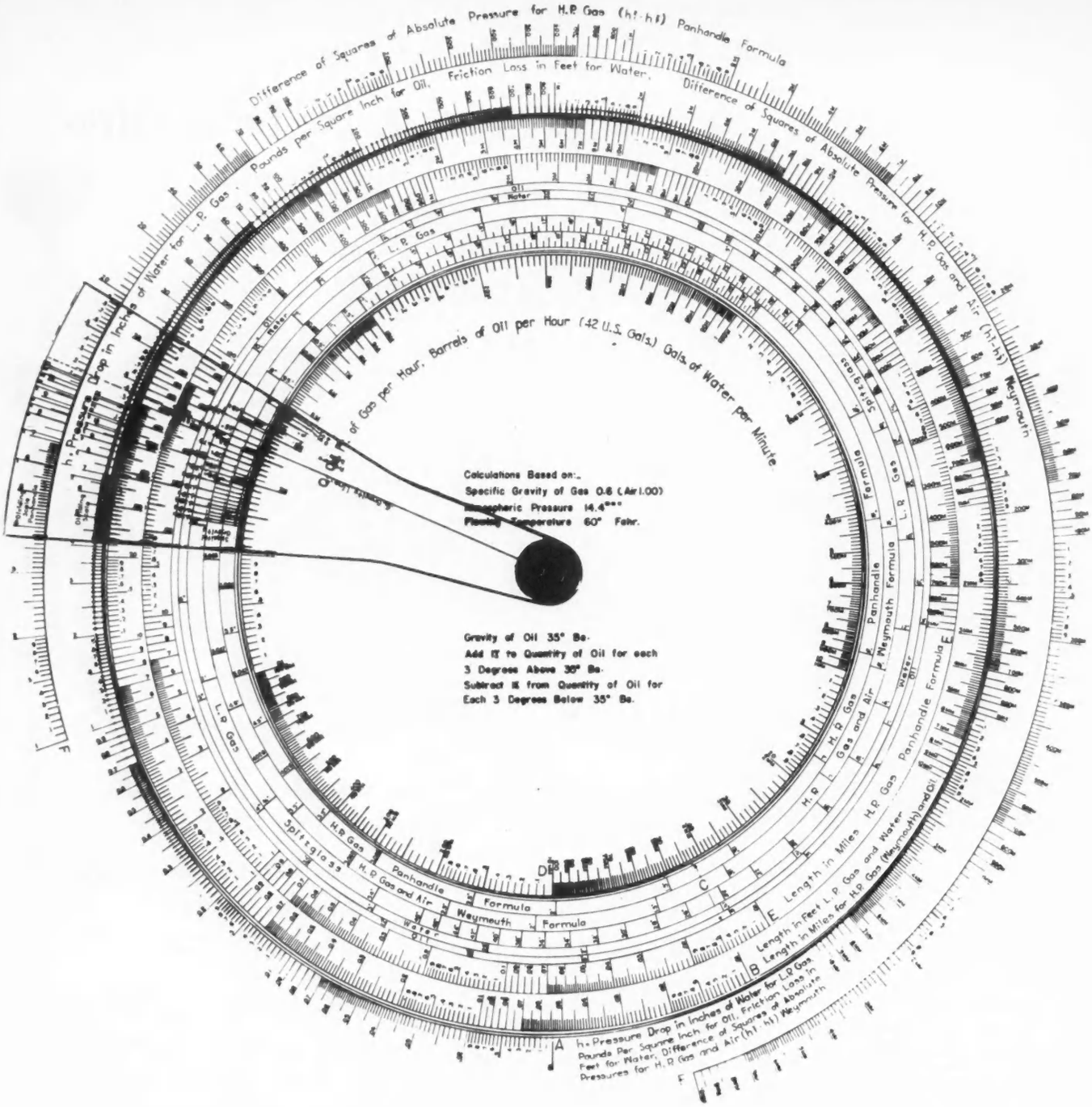
Difference of Squares of Absolute Pressure for H.P. Gas (h²-h²) Panhandle Formula
Pounds per Square Inch for Oil. Friction Loss in Feet for Water.
Difference of Squares of Absolute Pressure for H.P. Gas and Air (h²-h²) Weymouth
h. Pressure Drop in Inches of Water for L.P. Gas
of Gas per Hour, Barrels of Oil per Hour (42 U.S. Gals.) Gals. of Water per Minute
Calculations Based on:-
Specific Gravity of Gas 0.6 (Air 1.00)
Atmospheric Pressure 14.4 Lbs.
Flowing Temperature 60° Fahr.
Gravity of Oil 35° Be.
Add 1% to Quantity of Oil for each
3 Degrees Above 35° Be.
Subtract 1% from Quantity of Oil for
Each 3 Degrees Below 35° Be.
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L.P. Gas
Length in Miles H.P. Gas Panhandle Formula
Length in Feet L.P. Gas and Water
Length in Miles for H.P. Gas (Weymouth) and Oil
h. Pressure Drop in Inches of Water for L.P. Gas
Pounds Per Square Inch for Oil. Friction Loss in
Feet for Water. Difference of Squares of Absolute
Pressures for H.P. Gas and Air (h²-h²) Weymouth

Pipe Line Calculator

A CALCULATOR for determining pipe line flows of gas, air, oil and water has been developed by Robert M. Hutchison, director of research, Houston Natural Gas Company, which carries all its values on a circular unit, with a transparent lamination which protects scales. The calculator will solve problems in high-pressure gas pipe line flow by use of either the Panhandle or the Weymouth formula, and low pressure gas flow by the use of the Spitzglass formula.

Pipe line flow of oil is determined with the calculator through use of the National Transit formula, for which it is calibrated. The device will also correct for the specific gravity of gas, and for pressure base in gas problems, as well as for interval distribution in high or low pressure gas or water systems.

The Hutchison calculator is copyrighted, 1947, by its designer, and is distributed by him. It is made in one size, ten inches square, and comes complete with pressure table and instructions for its use. Although based on certain assumed basic values of specific gravity, atmospheric pressure and temperatures, simple algebraic corrections enable results obtained to be interpreted to cover any given set of conditions. Corrections are also given for gravity of oil differing by as much as three degrees, Baume, either way from the oil used as basis in the formulae. The calculator is accurate within the limits of the ordinary slide rule, and is equally useful for field and office flow computations of any of the types of pipe line throughput.

Pipe Lines of the U.S.

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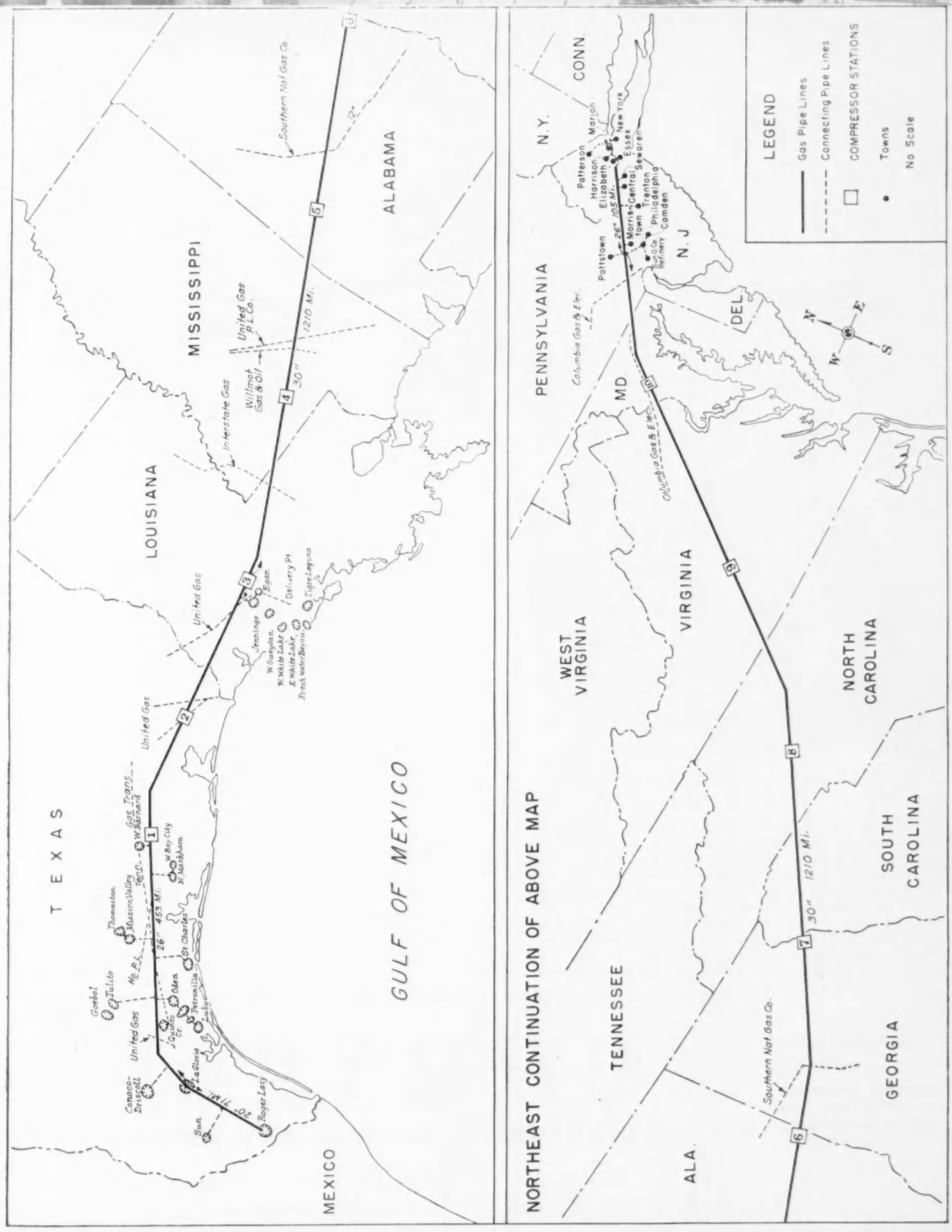

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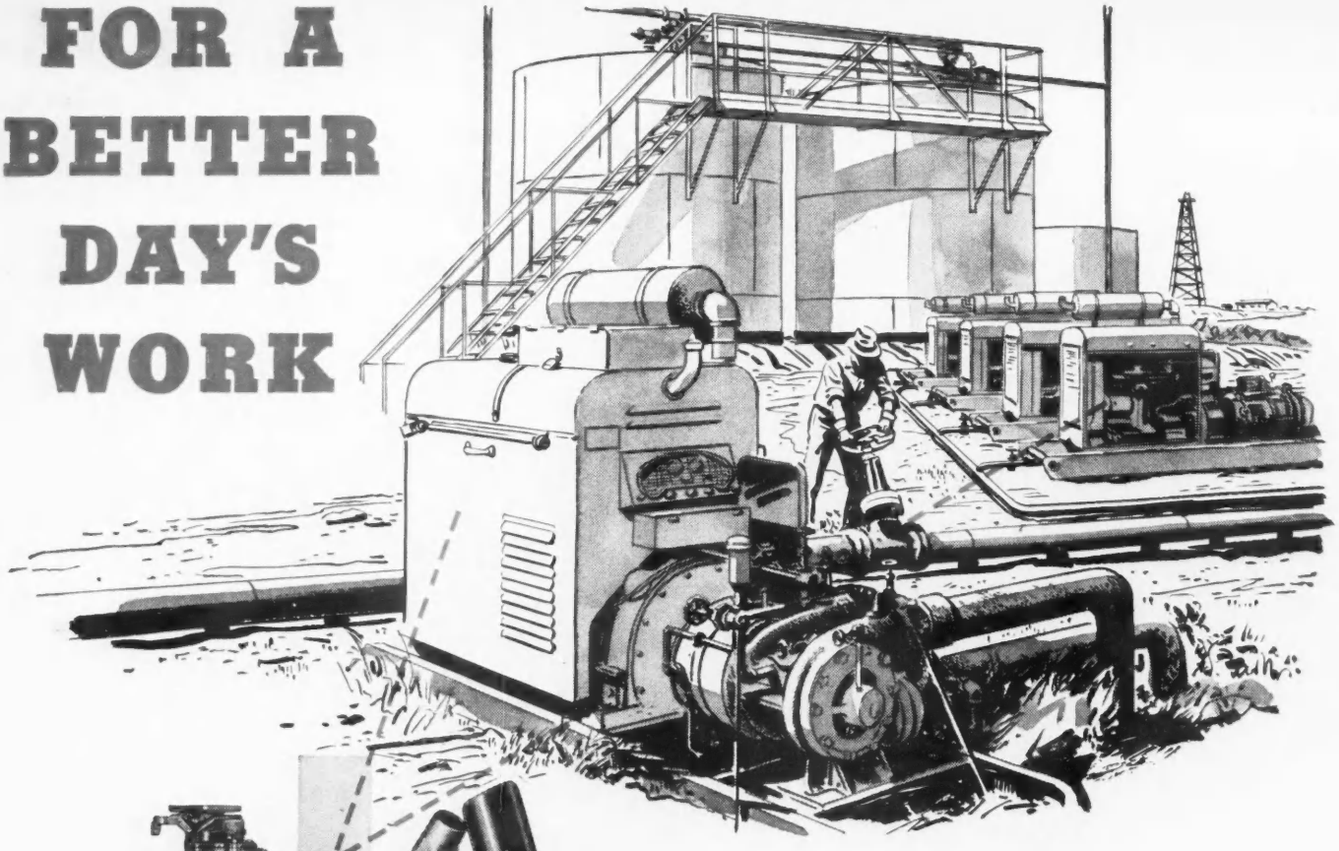

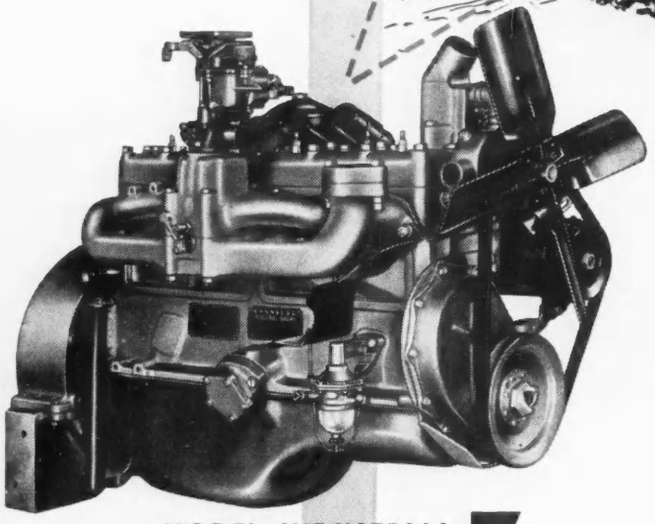

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PIPE LINE *Construction*

EXPANSION of the nation's natural gas transmission facilities in order to meet the rapidly growing demands for this convenient fuel is being delayed principally by shortages of steel pipe, according to a survey of natural gas pipe line construction made by the Federal Power Commission.

The survey covered 83 natural gas companies that had received FPC authorization to construct and operate new gas facilities between February 7, 1942, the time that present certificate provisions of the Natural Gas Act went into effect, and August 31, 1948. A total of 377 construction projects, involving an estimated total cost of $1,158,640,164, were covered by the survey.

By August 31 of last year, 288 of the 377 projects were completed, leaving 89 still under construction at that time. Of these 89 that were under way, 48 were reported to have experienced delays. In the cases of 38 of these, the delays were attributed to the inability of the various companies to obtain pipe. The remaining ten projects were hindered mainly by delays in securing compressors, machinery and other facilities.

Pipe requirements for the 89 unfinished projects total 2,184,585 tons, according to the survey, and of this, 821,447 tons, or about 37 percent, had been delivered by August 31. Estimates on future deliveries indicated that the builders expected to get nearly 238,000 tons during the remaining four months in 1948, about 518,000 tons in 1949, and a little over 444,000 tons in 1950. However, one large pipe line company could not give a definite delivery date for the 80,290 tons of pipe needed to complete one of its projects, and several other companies reported that orders for their combined requirements of 73,405 tons had not been placed and accepted. Assuming that deliveries for the remainder of 1948 lived up to expectations, these 89 unfinished pipe lines started the new year with 48.5 percent of their total requirements on hand, with the balance of 1,125,232 tons, or 51.5 percent yet to be delivered.

Companies reporting to the FPC survey reported that up to August 31 expenditures on the 377 pipe line projects amounted to $624,589,278, or 53.9 percent of the total estimated cost, and that it would necessitate spending $534,050,886 more to complete them. The survey report also showed that $289,457,140, or 46.3 percent, of that already spent went into projects that were completed by August 31, 1948, and the remaining $335,132,138 were expended on unfinished construction. The above 89 uncompleted projects will represent investments amounting to $869,183,024.

Besides the pipe line projects now under way, FPC had applications on October 13, 1948, for 55 additional lines yet to be acted upon. Twenty-one of these applications were for major projects requiring approximately 2½ million tons of steel pipe. The Commission also pointed out in its report that some companies had placed pipe orders for lines on which applications had not been filed.

Pipe shortages will not confront the successful bidder for a 100-mile natural gas transmission line in Louisiana being offered for sale by War Assets Administration. The government-surplus line starts near Lake Charles and extends to the communities of Woodlawn, North Tepetate, Lakeside and Chalkley. The line is being operated for the government by Union Sulphur Company and receives gas from six suppliers. Bids for this line will be received until February 10.

PIPE LINE CONSTRUCTION

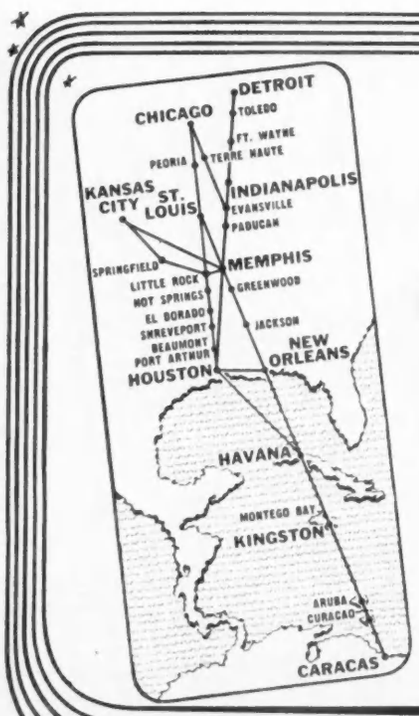
Table includes projects planned, contracts awarded, and spreads or entire projects completed since the last issue of WORLD OIL

COMPANY	Origin and Terminus	Length, (Miles)	Pipe Size, (Inches)	Daily Capacity (Barrels Cu. Ft.)	REMARKS
CRUDE OIL LINES					
Atlantic Pipe Line Company	Block 31 field, Crane County, West Texas to Refugio, Texas	382	10	45,000	Started by A. C. Holder Construction Co., Tulsa, Okla. Completion scheduled for end of August, 1949.
Attock Oil Co., Ltd	Balkassar field in Pakistan to the Dhulian-Rawalpindi pipe line	34			Completed in late 1948. Construction was started in 1947 but as delayed by internal difficulties of the country.
Cooperative Refinery Association.	Valley Center, Kansas to Hooser Station, Cowley County, Kansas	40 20	6 8	8,800	Completed in December by Jayhawk Construction Co., Great Bend, Kansas.
Creole Petroleum Corporation	Ule tank farm, Lake Maracaibo to Amuay Bay refinery, Paraguana Peninsula, Venezuela	155	24 & 26	200,000	Completed in December by Williams Brothers Corp., Tulsa
Nederlandsche Nieuw Guinee Petroleum Mij	Klamono field to Sorong Terminal on western tip of Netherlands New Guinea	32	8		Completed in December by company crews.
Ohio Oil Company	East Sparta, Ohio to Canton, Ohio	6	6 & 7		Sheehan Pipe Line Construction Co., Tulsa, started construction in January, 1949.
Sohio Pipe Line Company	Taking up of gathering lines in Illinois, Indiana and Kentucky	40	2 to 6		Started by Somerville Construction Co., Ada, Michigan, in December. Will complete February 1, 1949.
Texas Pipe Line Company	Patoka, Illinois to Wood River, Illinois	55	22	84,000	Sheehan Pipe Line Construction Co. started work in January and will complete by end of May, 1949.
PRODUCTS LINES					
Socony-Vacuum Oil Company, Inc.	Branch extending from Malvern-Binghamton line and known as Reading Spur	22	6		Midwestern Constructors, Inc., Tulsa, has contract, but bad weather holding up start.

PIPE LINE CONSTRUCTION—*Continued*

Table includes projects planned, contracts awarded, and spreads or entire projects completed since the last issue of WORLD OIL

COMPANY	Origin and Terminus	Length, (Miles)	Pipe Size, (Inches)	Daily Capacity (Barrels Cu. Ft.)	REMARKS
NATURAL GAS LINES					
Central Gas and Electric Company	Company's emergency plant to Army Air Base, Lincoln, Nebraska	6½	6	.....	Completed in December by Wilson Construction Co., Tulsa.
Cities Service Gas Company	Hugoton field, Ulysses, Kans. to Hutchinson, Kansas	183	26	.....	Both lines completed in December by Ray L. Smith & Son, Inc., El Dorado, Kansas.
	Hutchinson, Kansas to Newton, Kansas	22½	26	.....	
City of Lincoln, Nebraska	City's meter station to the Army Air Base	8½	6	.....	Completed in December by Wilson Construction Co., Tulsa.
Home Gas Comapny	Compressor station in Steuben County, New York	..	.....	.....	Construction of this 300-hp compressor station has been authorized by the Federal Power Commission.
Manufacturers Light & Heat Co.	Existing line near Canonsburg, Penna. to Pittsburgh area	10½	12	.....	Authorized by Federal Power Commission.
	Steubenville, Ohio to Wintersfield, Ohio	5	6	.....	Authorized by Federal Power Commission.
	334-hp compressor station in Marshall County, W. Va.	.....	.....	.....	Authorized by Federal Power Commission.
Michigan Gas Storage Company	Freedom Station, Pleasant Lake, Michigan to Laingsburg, Michigan	61	20	.....	Construction started in December by E. J. Mahoney Contracting Co., Mt. Pleasant, Mich. This $3½ million project is scheduled for completion first of June, 1949.
	Laingsburg, Michigan to Lansing, Michigan	14	12 & 20	.....	
Missouri Utilities Company	TETCO line near Illmo, Missouri to Cape Girardeau, Mo.	8½	6	.....	Work started by Midwestern Contractors, Inc., Chicago To be completed by Mid-February.
Natural Gas Co. of West Virginia	Brinker Station, Ohio to vicinity of Salem, Ohio	5	8	.....	Construction authorized by Federal Power Commission.
Northern Natural Gas Company	Gathering system in Hugoton field, north of Sublette, Kans.	18	4–6–8	.....	Completed in December by Brodie Construction Co. Amarillo.
Phillips Petroleum Company	Gathering systems from Texhoma (Hansford Plant), Okla.	90	8 to 24	.....	To be completed about Feb. 1, 1949 by Vaughn & Taylor Construction Co., Inc., Wichita Falls, Texas.
Public Service Co. of Northern Illinois	Marseilles, Illinois to Seneca, Illinois	6	6	.....	Completed in December by Midwestern Contractors, Inc.
	Oyyawa, Illinois to Wedron, Illinois	6	12	.....	Same contractor completed in January.
Southern Counties Gas Co. of California	Texas-to-Calif. pipe line at Moreno, Riverside County to San Diego County line, California	35	16	40 mln	Application made to Federa Power Commission. San Diego Gas and Electric Co. will apply for 50 miles to continue line into San Diego.
Texas Gas Transmission Corp.	Lula, Miss. to Memphis, Mississippi	63	26	62½ mln	This completed line is a gas storage system tying into Memphis' distribution system. Will eventually become part of 800-mile Texas-to-Ohio project. N. A Saigh Co., San Antonio, and Horrigan Construction Co., Houston, were the contractors.



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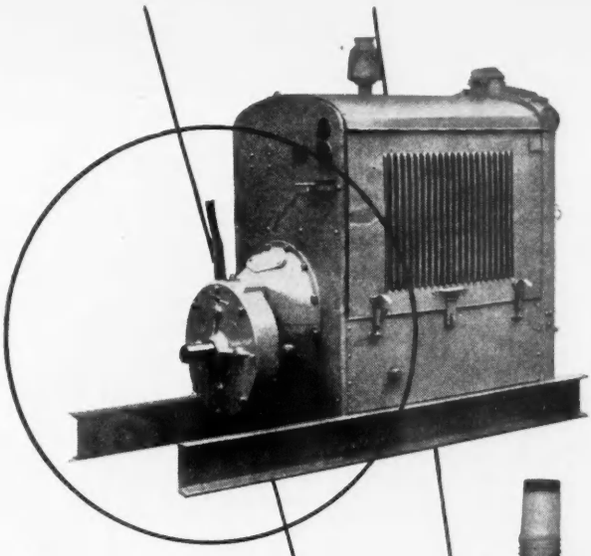
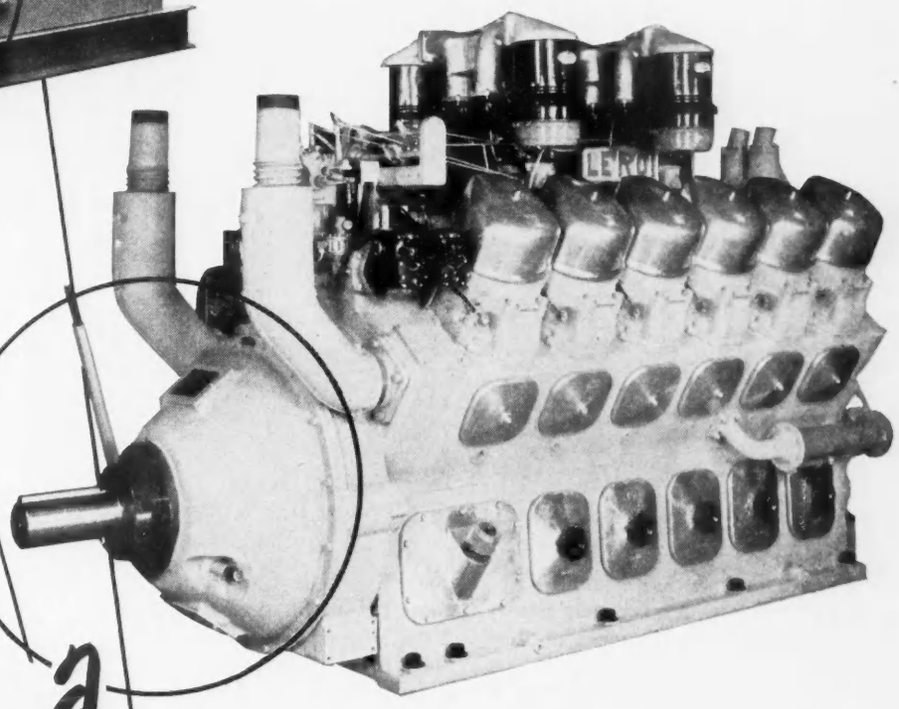


Le Roi Model 2C Power Unit

Le Roi's L-3460 Engine



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Nearly 30 years later Le Roi designed the L-3460, a V-12, 600 hp natural gas, butane, or gasoline engine for the petroleum industry. *This Le Roi Engine uses a Twin Disc Power Take-off for power transmission.*

For three decades manufacturers of heavy-duty equipment, revolutionizing American industry, have found Twin Disc Clutches and Hydraulic Drives efficient power transmission units. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

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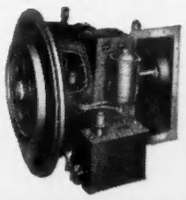
Power Take-off

Hydraulic Torque Converter



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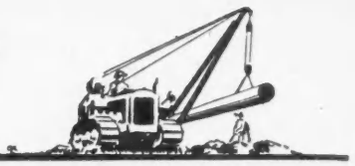
How to do it!

PIPE LINE HINTS



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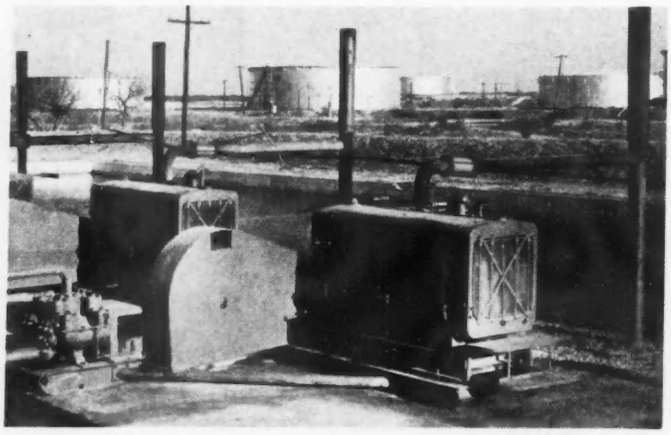
HOW TO—Maintain Engine-Pump Alignment at Pipe Line Stations

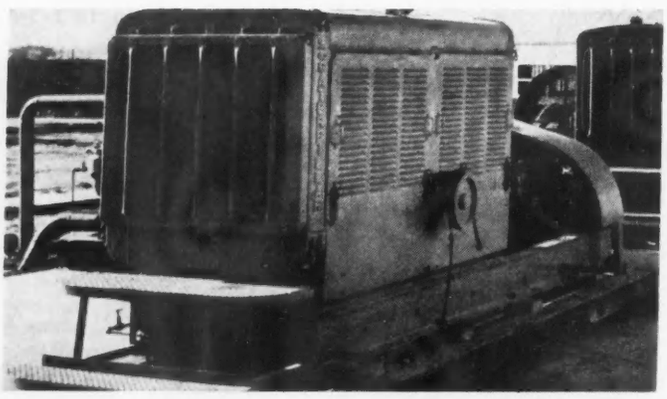


Numerous installations in the field and at pipe line pumping stations require a battery of relatively small pumping units operating in parallel. Normally, these pumps and their prime movers, such as those illustrated, are separately mounted on individual steel beam skids to facilitate moving. For the most part, these combination units operate on a 24-hour basis, and as such, it is necessary that proper alignment be maintained between the two units. Since the prime movers are not necessarily bolted firmly to the concrete foundation, and therefore being somewhat of a temporary nature, this alignment has been insured by a 45-degree angle brace bolted to both units.

As shown, the brace is a section of 2½-inch pipe to each end of which a square plate of steel has been welded at an angle of 45 degrees. Four holes in each corner of the plate accommodate bolts for securing the brace to the runners of each skid.

Important also is the muffler assembly. The design shown produces maximum silencing through the use of pipe materials. The relatively large diameter upright supporting the muffler acts as a surge chamber for the pulsating exhaust gases. A slightly larger pipe approximately four feet long, has been belled to fit snugly around the upright member extending inside the larger pipe for one or two feet. Holes have been cut into the outer pipe where the two join at the belled juncture. These openings permit air to be sucked in as the exhaust is blown into the air, thereby acting as a dampener. In this manner, exhaust noises from the battery of engines are materially reduced. The sleeve coupling on the exhaust line facilitates removal of the prime mover for repairs and overhauls at the station shops.

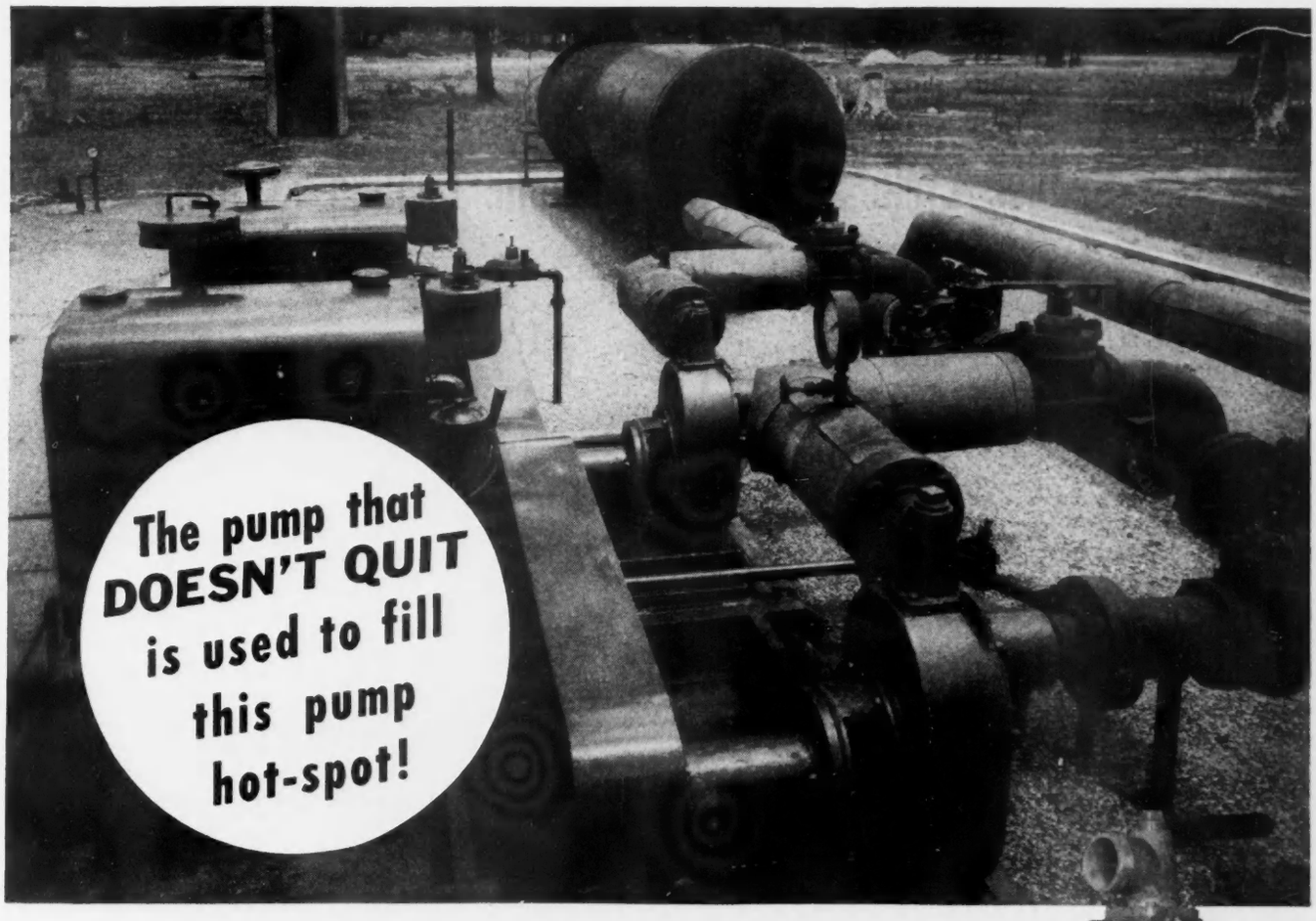
HOW TO—Add Prefabricated Service Steps to Pump Engines



A pipe line company has reduced stumbling hazards by providing a platform from which to service the cooling system of pump engines. Prefabricated steps ready-made in the shops to fit a particular make engine were added to the front of the power unit in order that maintenance crews could periodically check the cooling system and in winter change the fluid.

The step faces are made from regular floor plating material cut with rounded corners so the square point is eliminated, and thereby further reducing a possible hazard. The outer edge of each step is supported by a corresponding curved piece of angle iron which is tack-welded to the under side. Horizontal members which carry the load of anyone placing their weight on the steps are welded to the inside of the horizontal I-beam framework of the engine foundation. The top step is welded to the engine frame to provide the necessary support. With steps thus placed, it is impossible to crank the engine in the normal manner. However, smaller starting engines have been added to do this job and the starting wheel for the smaller engine may be seen at the side of the large engine cover.

Belt tension is maintained by a unique method employing two large screw bolts at either end of the engine base. The backup or stationary element of the device is a supported vertical arm through which the tightening screw fits. Bolts have been placed in the engine base and have nuts which bear against the backup member. When it is necessary to tighten the belts, the job is done simply by tightening each nut to the required tension.



THE job of circulating hot water for an indirect emulsion heater is a hot spot for a pump. It is one oil country service in which pumping can never be faulty or inefficient. Temperatures of the treating tank *must* be kept uniform by a constant hot water flow.

In this treating installation at Ville Platte, Louisiana, two belt-driven Marlow Self-Priming Centrifugal Pumps, Model 34, are used by Continental Oil Company to handle this critical operation. It is one of four such crude oil emulsion heater systems on Continental leases in the Ville Platte area . . . and Marlows are used in them all.

The main reasons? Smooth, uninterrupted flow is assured with a Marlow Self-Priming Centrifugal — the pump that doesn't stop pumping. There is nothing to manipulate. No parts to jam or cause trouble. A Marlow's capacity can easily be varied for temperature regulation by simple valve control of water flow to the pump's suction inlet, the power unit being set at a constant economical speed. If water flow should be interrupted, when it resumes, the Marlow will automatically continue its smooth, even discharge.

There are a number of other reasons. Ask about them all at your nearest Marlow dealer.

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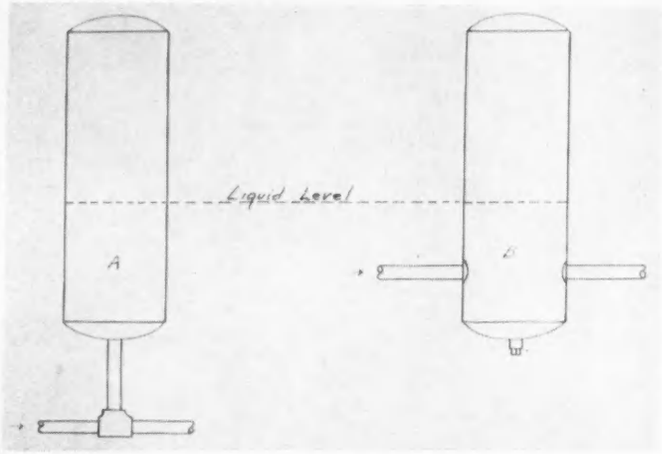
HOW TO—Reduce Cyclic Surge in Hydraulic Cooling Systems

The mechanical disadvantages of cyclic surges in hydraulic systems are well known to pipeliners. The force behind continuous throbbing of fluid in these systems is sufficient to do considerable damage to piping connections, valves, and other components of the system.

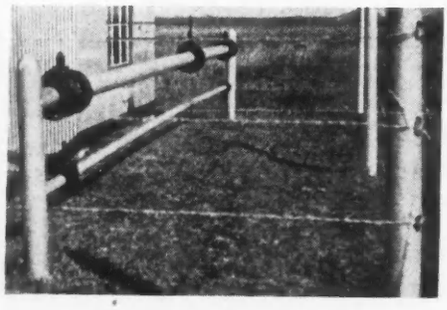


Considered somewhat a standard method of reducing hydraulic surges in systems where the fluid is circulated by two-cylinder positive displacement pumps is the inclusion of a surge chamber containing an elastic medium which absorbs irregular pressure levels. The usual manner of connecting such a surge chamber is by merely adding a tee in the line and connecting the line into an elevated air-filled chamber. While this method is effective in reducing the surges in the system, the smoothing-out effect of the elastic medium is not as effective as it might be, since the connecting line to the chamber acts like a choke. The rise and fall of pressures above and below line pressures is exerted over a relative small cross-section, i.e., the area of the small pipe connecting the chamber to the line. This method is illustrated in Figure A of the diagram.

Utilizing actually fewer fittings for installation, and at the same time acting more effectively to reduce pressure surges, is the method shown at right as Figure B. In this instance, the fluid level in the chamber is at the same height as in the case mentioned above. The difference in installation is that both intake and exhaust lines from the chamber are welded directly to the chamber walls, making it necessary for the circulating cooling fluid to pass through the chamber. Such installation provides a larger area on which the surges may act, without producing a "choking" effect. This type surge chamber has proven superior to the method in Figure A, and actually requires less time and fewer fittings to install.

HOW TO—Keep Leaking Gas and Piping Out of Meter House

For many years, meter houses have been built right over the meter run and the pipes clutter up the inside of the meter house and small leaks in gaskets are collected in the enclosure. One company broke away from tradition and put the meter house adjacent to the meter run and piped the quarter-inch pressure lines and the copper tubing to the recording equipment inside the building. A neat arrangement results with the instruments mounted on the walls and a convenient place provided for the meter man to make his reports, etc., without fear of being overcome with gas. Foundations and erection of the building are simplified besides keeping the building intact for moving without having to dismantle it. A fence is built around the meter run to prevent unlawful entry and the meter house is locked. However, in an emergency the valves can be reached by anyone familiar with the piping, and it is not necessary to enter the meter house to shut off the line. If it is necessary to change the size of the meter run, it can be accomplished without disturbing the building.



HOW TO—Make Spare Tire Rack

The spare tire of the typical oil field truck is a space-consuming item which generally has to be shifted from one position to another as the size and type of loads may dictate. One company solved this problem by devising a rack which allows the tire to be mounted in a horizontal position atop the truck cab. Made of two-inch pipe, the rack is actually made a part of the structure surrounding and protecting the winch unit. It does not require bracing for the pipe is bent through 90 degrees in a gentle arc and supports the tire. A flat plate containing the holddown bolts is welded across the two arms. In this position, the tire is out of the way, yet easily accessible.

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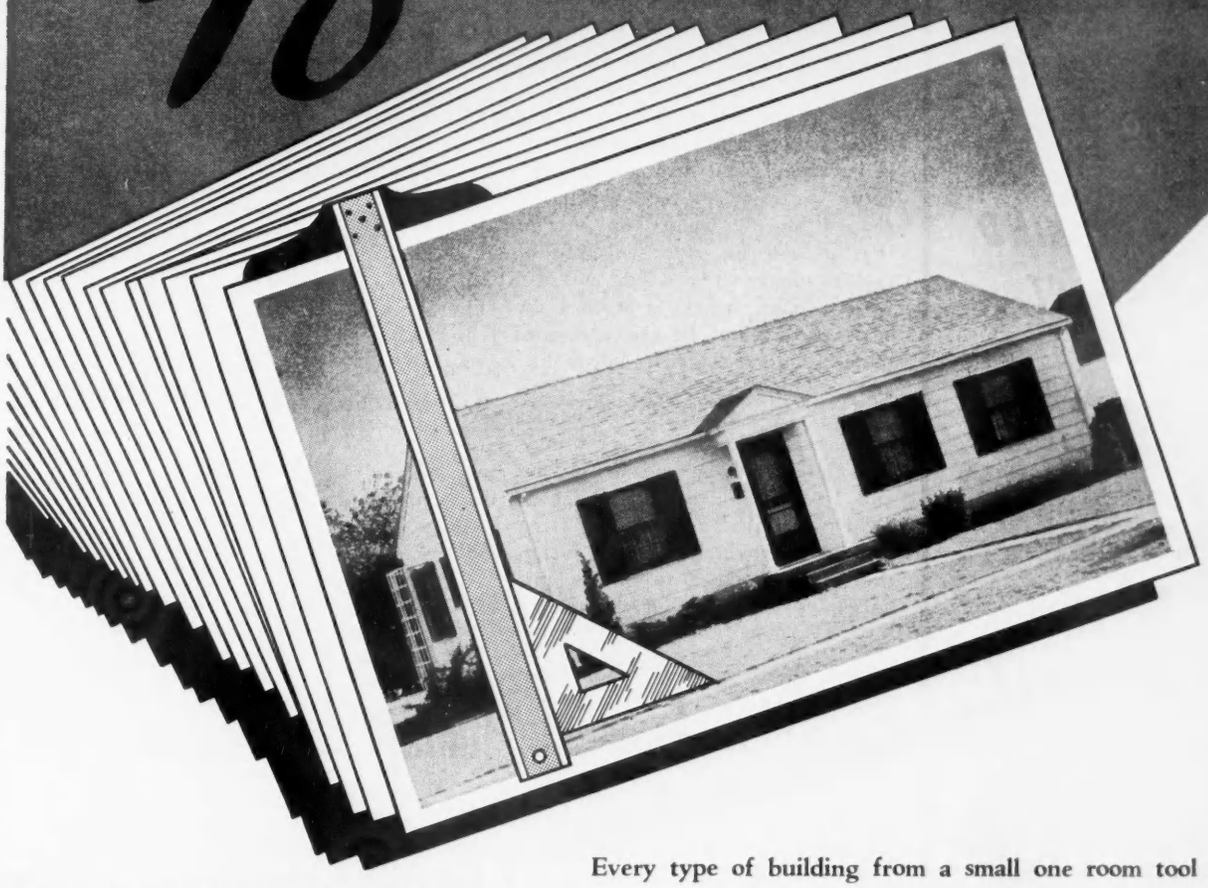

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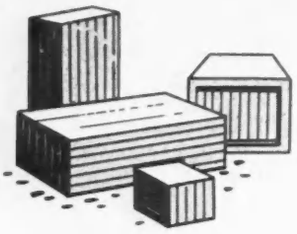

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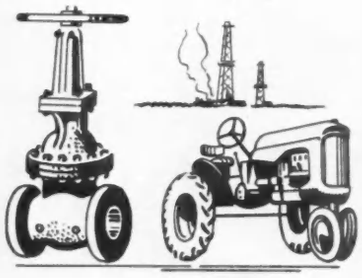

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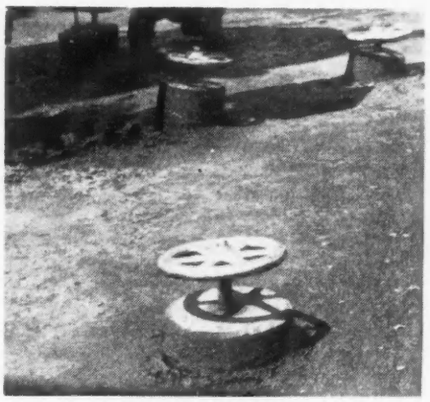
HOW TO—Protect Packing Glands of Valves

Where the pipe lines around the tank batteries of one company are buried, the packing glands of the valves are protected from corrosion by a cap which fits down over the gland before the ditch is backfilled. The cap is made from a scrap piece of six-inch pipe which is shaped by the welder on one end so that it will fit over the gate bonnet rather snugly. The other end is fitted with a plate which is welded on and seals the casing. In the center of the plate, a hole is drilled to allow the valve stem to pass.



These caps are made up in the shop using various lengths of scrap pipe with the plates welded and drilled on one end. In the field, the cap is then cut the proper length to protrude from the ground approximately three inches and the bottom shaped to fit the valve. If necessary, the stem of the gate is extended by brazing on a bar the same size as the stem, which raises the valve wheel approximately four inches above the top of the plate. After the valve stem is properly packed and lubricated, no further attention is necessary.

HOW TO—Assemble Handy Shop Welding Jig

Where parts are to be welded around a circumference, and need to be rotated during the welding process, a jig may be easily assembled from a junked automobile hub as shown in the photo. The

axle of the front wheel is mounted on the work bench, and the hub without the wheel is placed on the bearings. Where the grease retainer cap screws on, the welding torch may be used to supply the necessary assembly to properly hold the parts to be welded.

In the illustration, gas lift valves are being welded to seal the bellows chamber after the valve is set to operate at the desired pressure. A two-inch nipple surmounted by a 2½-inch nipple is used to hold the assembly erect. Where flat pieces are to be welded, a table with one leg is used, the leg being in the center and sticking down into the previously provided well. The bolts which were used to hold the wheel become pegs for easy adjustment of the position of the jig. The complete jig is bottom-heavy, thereby making it an excellent base for holding parts to be welded. It is well balanced, and can be easily rotated as the torch is applied.

Trading Post Ahead!

PAGE 262

NEW GUINEA OIL Goes to Market

THE first shipment of crude to leave New Guinea has been loaded aboard a tanker at the terminal port of Sorong on the extreme eastern tip of the island, destined for refineries elsewhere in the East Indies. With this cargo, the Nederlandsche Nieuw Guinee Petroleum Maatschappij has placed the world's second largest island on the list of producing areas of the Far East. The first commercial cargo also represents the success of one of the most difficult exploratory operations ever undertaken.

It represents the culmination of 12 years of exploration, interrupted in 1941 by the Japanese invasion, and only continued in 1946. Now a road and pipe line have been built from Klamono to the coast and the beginning of this year saw the potential of the one producing field brought to 4000 barrels a day. At the time operations were abandoned in the face of Japanese aggression, it was estimated that nearly $14 million had been spent without a barrel of oil going into the market.

The Nederlandsche Nieuw Guinee Petroleum Maatschappij was formed in 1935 by affiliates of the Shell Group, Standard-Vacuum Oil Company, The Texas Company, and Standard Oil Company of California. Bataafsche Petroleum Maatschappij, the Shell affiliate, owns a 40 percent interest in NNGPM and has charge of all operations, including exploration and development. Standard-Vacuum owns 40 percent, and the other 20 percent is held by Far Pacific Investments, Inc., which latter is owned by Standard of California and The Texas Company.

A concession covering roughly one-fourth of the entire area of Netherlands New Guinea was taken in 1936, most of the area under study being situated in the southern half of the Vogelkop, or "bird's head," and extending on down along the southern coast. The total concession area is equivalent to about one-quarter the area of California.

Starting From Scratch

The NNGPM started exploration of this area from scratch. Such geological information as was available on New Guinea was extremely sketchy, and maps of the area were incomplete and misleading. The terrain is about as uninviting as any upon which exploration has ever been attempted, and adequate roads simply did not exist. It is extremely rugged, covered by dense, tropical rainforest and subject to year-round rainfall.

With a view to obtaining as much basic information as possible within as short a time as possible, it was decided that the best starting point would be a geologic examination of aerial photographs. The aerial survey thus instituted was one of the first large-scale mapping programs undertaken for that purpose. Normally, with the equipment developed at that time, it would have been possible to cover an area of this size within a comparatively few weeks, but in New Guinea territory, lying almost exactly athwart the Equator, presented vastly complicated problems. Constant rains, intermittent storms, and cloudy skies so limited the activity that nearly two years were required for the completion of the actual photography, with an average over this period of no more than 30 minutes flying time a day. Base maps were made up from the photographs, and it was only then that the field work could get under way. The Klamono field, near the western tip of the Vogelkop was the first discovery, largely because of the possibility of access by river transportation. The Klasafet River flows near

This hand-operated rotary is the heaviest rig that can be used in some remote areas.

Oil company geological camp on Klasafet River.

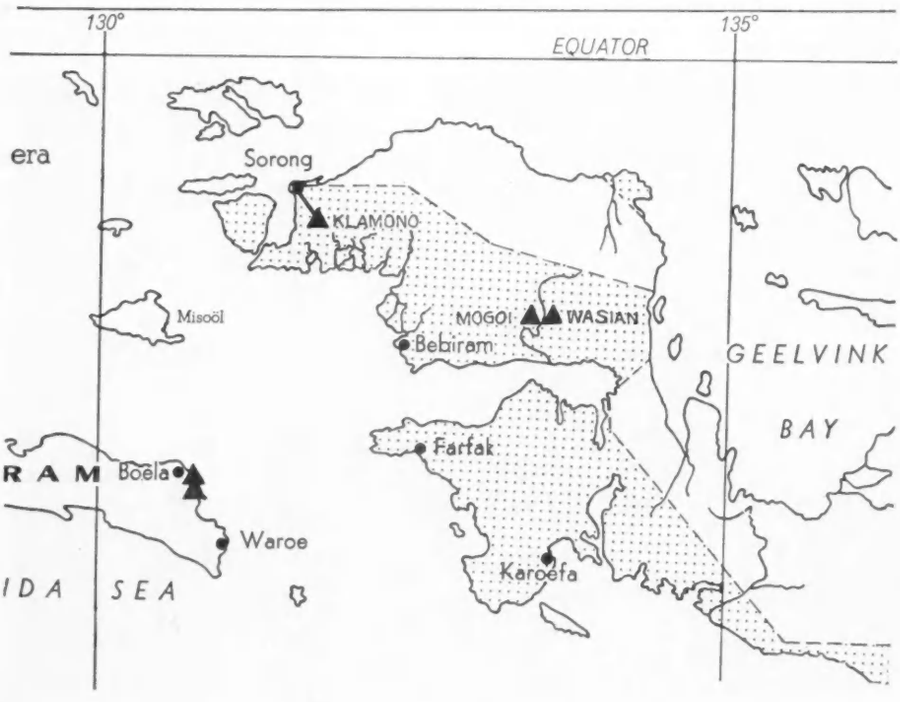
the field, but even this is only navigable by small boats. It furnished a communications line, but very little assistance in getting heavy machinery in to drilling sites.

The first drilling crews were faced with almost the same problems in logistics as are encountered by invasion crews during wartime. Each unit had to be self-contained, able to carry and use its own roadbuilding and maintenance equipment as well as all other equipment necessary to sustain itself in the field. The equipment included not only the drilling machinery but also food, clothing, medical supplies and recreational facilities. Between the time exploration started and the beginning of World War II, three fields had been discovered; one at Klamono, and others at Mogoi and Wasian, about 150 miles southeast. The Klamono field, being most easily accessible, received most of the development, with eight producing wells out of a total of 14 drilled prior to the war. Actual production had to wait for completion of transportation and storage facilities.

Klamono field was found at a shallow depth, producing heavy, 19-gravity crude from 300 to 650 feet. It was fortunate that this shallow drilling was possible, since the equipment was limited in size to that which could be transported over crude trails. Now it should be possible to explore for deeper horizons, since a road was constructed from the base camp and terminal at Sorong as a necessary part of the program to build a pipe line outlet. The building of this road was a project within itself, even with bulldozers and other modern road equipment, since during its construction there were very few periods during which the ground was dry. New Guinea mud is the ultimate in sticky, slippery impassability. With completion of the road in recent months, the operators proceeded with laying an eight-inch line from Klamono to the new marine terminal at Sorong, 32 miles away. Meanwhile drilling has proceeded, mostly within the past few months, and some exploratory drilling is being carried on at the prospect of North Klamono.

The entire operation outside of the geological records and maps was a repetition of the work done prior to the war. At the time the Japs came a full-scale denial plan was placed in effect. Personnel were evacuated, and all physical equipment used in the operation was destroyed and materials not transportable were dumped in the river. This meant that when the operators re-entered the area in 1946 they had to bring everything.

There are now six drilling rigs in the concession area, three of which are post-war. All are of the portable or semi-portable type and all are power rigs. It is possible to move these about to some extent in the areas of Klamono, Mogoi and Wasian, since the latter two are located on another river, the Temboeni, navigable during the periods of high water. However, a real need is for a highly portable rig for exploratory use, preferably one which can be broken down into parts which can be hand-carried. This can be done with many parts of the rig, but the power units and pumps present a problem not yet solved. Field geological parties have located a number of structures, and have done some work with hand-operated coring outfits, but there remains the big problem of getting an adequate drilling rig to remote locations.



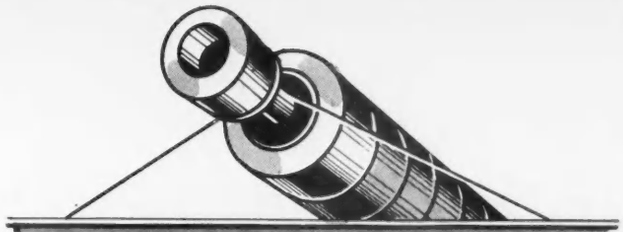
Map shows area under concession to NNGPM, location of present fields and pipe line from Klamono to Sorong Terminal.

Character of Oil

The three areas already discovered have accumulations in the same formation, although the character of the oil is not the same in all cases. All have oil in what has been termed the Klasafet Limestone of Miocene age, and all are structures of anticlinal nature. Wasian's oil is found at 2900 to 3225 feet, gravity about 48 degrees, and has a paraffinic base. Mogoi's oil is a 46-gravity paraffinic base fluid found at about 1250 feet. Production from Klamono is much heavier, averaging 19-gravity with asphaltic base. Although it produced only for field use up to the time the pipe was completed, Klamono reached a total of 12,295 barrels cumulative production by the middle of 1948. Structures for living quarters in field areas are necessarily of semi-permanent nature since they must be built on concrete foundations. Anything else falls easy prey to armies of termites.

The NNGPM terminal and camp at Sorong started as a tiny missionary settlement and wound up as a large base camp for an army of American, European and New Guinea workers. Men, foodstuff, supplies and construction equipment were first assembled at a staging area at Morotai, on an island offshore, and then moved 300 miles to Sorong by plane and barge as the jungle was slowly pushed back to make room for docks, housing, storage tanks, and workshops. At times during the heavy periods of construction there were as many as 9000 workers in the Vogelkop area. At latest available count there were about 400 Americans and Europeans and 6000 Indonesians regularly employed in New Guinea by the NNGPM Communications between headquarters base camp and field operations are maintained through the use of radio, telephones, aircraft and boats.

One of the pressing needs, and one slated for attention within the near future is for a road from the coast to the fields of Wasian and Mogoi. This access route probably will be built from a point on the coast about 200 miles southeast of the camp at Sorong, at which point the fields are no further inland than is Klamono. It is understood that the chances for commercial production at Wasian are particularly good, but active development will have to wait for a road over which the heavier equipment required can be moved.



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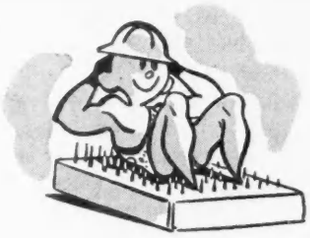

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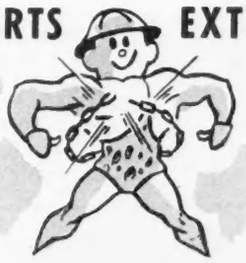

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Problems in Canadian WINTER Operations

By
ROY E. LEIGH

Clearing roads in Alberta oil area.

CANADIAN oil operators, as graduates of Turner Valley and Petrolia School of Hard Knocks, and having done post-graduate work in the University of Experience, at Norman Wells, in the Yukon, have evolved methods for combatting the sub-zero temperatures of the Western Provinces, which may range as low as 45° F. below zero at Leduc, Central Alberta, and minus 50 or 60 degrees in the Lloydminster field, eastern Alberta and western Saskatchewan.

In all field operations, special precautions must be observed and special facilities are required to protect the men and equipment. In drilling operations, from spudding to swabbing in, steam coils are an essential feature of every step taken during the frozen winter months. Likewise in production operations, in every step from well-head to pipe line; and, even in pipe line practice, oil must be heated to a uniform temperature to protect the line against damage which might be caused by expansion and contraction arising out of the movement of oils of differing temperatures.

Beginning with drilling operations, wherein the most severe rigors of winter are encountered, the first step is represented by the enclosure of each unit of equipment, including the boiler house, if steam rigs are used, or the engine house, if diesel power is employed. Mud pumps are housed, as are mud mixers, electric generators, and all auxiliary equipment; and other structures include a heated dog house for the protection of the men, dressing rooms, tool houses, etc. Mud mixers and suction pits are placed inside the pump house for protection against freezing.

The digging of sumps and pits presents a major problem in bulldozing when the earth is frozen to a depth of five feet. Water supply is another difficult feature of wintertime drilling, as the deep frost precludes the operation of a water pipe line system. Water must be hauled in tank trucks, which frequently must be thawed out with steam jets. Exhaust steam, from the various heating coils around the drilling rig, or tank battery, is vented into the water supply tanks to keep their contents warm and liquid.

A radiator mixture containing 50 percent of ethylene glycol is used in the cooling systems of internal combustion motors, bulldozers, tractors, trucks, and automobiles; and the motor blocks of such equipment are further protected by electric heaters of various types, one of which contains a heating unit which is a permanent fixture of the lower radiator hose-connection. Another is composed of electric heating elements which are fastened to the outside of the motor blocks. These are connected to electric supply lines at night, when not in use, or whenever possible.

Bulldozers are needed in all types of winter operations, for clearing away snowfall, snowdrifts, repairing road surfaces, etc.; and tractors are no less imperative for moving equipment, especially during the spring thaw.

During the drilling phase, the first girt of the derrick is enclosed by sheet iron, wood panels, or canvas windbreaks;

AS DEVELOPMENT and production operations are carried on throughout the severe winters of the Canadian prairies, elaborate precautions are necessary to maintain operations. The digging of sumps and pits is a major achievement, and maintaining a supply of water is often well-nigh impossible. Also difficult are operations during the Spring Thaw, when the snow melts and cannot be absorbed by the frozen ground. This article points out the solution to these and other problems encountered in the area.

Left: Serious transport problems provided by Spring Thaw after ground has been frozen to a depth of five feet.

and the thribble board is enclosed on four sides to give as much protection as possible to the derrickman.

Men are especially trained to wear proper shoes and clothing, and to take all precautions against frostbite. They are taught that they should not hurry, run, jump, or over-exert themselves during severely cold weather, as heavy, rapid, or deep breathing may bring in so much cold air as to freeze their lungs. All work is done at a moderate, measured pace. It is said that experiments conducted by the U. S. Army have indicated that at 60° F. below zero, a healthy man's body generates barely enough energy to sustain its basic functions of breathing, heart action, digestion, etc. Thus, at around minus 45° F., a workman is only about 50 percent efficient. So drilling operations, perforce, are slowed by 50 percent, as compared to the summer and autumn seasons. This doubles the cost of labor and fuel employed in drilling operations during the five months of the Canadian winter.

Notwithstanding this and other difficulties of low temperatures, drilling is continued right through the winter. In the new field at Leduc, for example, 5300-foot wells which may be completed in 30 to 35 days or less in summer, may take up to two months during the winter.

Low-pressure boilers, not requiring the attention of licensed firemen, are a prime feature of all drilling, production, and gathering operations. Steam lines are laid in the same ditches with pipes carrying water, fuel gas, and Diesel fuel; and the suction line of the mud pumps, always the first to freeze, is similarly protected. Discharge lines from the pumps do not require protection so long as circulation is maintained, as the mud is warmed by pressure but after a shutdown, it might prove necessary to thaw discharge lines as well as the mud pits themselves with a steam jet. During short shutdown periods, circulation must be maintained through the kelly joint, even when it is in the rathole; and the mud pumps must be kept in operation at idling speed to forestall freezing. If longer shutdown periods are anticipated, the kelly, pumps, and everything else must be drained of mud and water.

Slips, tongs, and tools may freeze to the derrick floor in a moment's time, making necessary the use of a jet of live steam to free them. Acetylene torches are used to warm up all units of mechanical equipment so that they may be started again after having been shut down for any length of time. Notwithstanding all the protection and precautions which can be devised, there is still plenty of grumbling when the graveyard shift has to turn out into the darkness to face a biting blizzard at 40 below.

However, Canadians are quick to defend their weather. They explain that, when the mercury is at its lowest, everything is dry and hard under foot. Snow is like dry dust, and there is no mud and slush.

Spring Thaw Worst

The worst and most difficult phase of the Canadian climate occurs during the Spring Thaw of April and May, which is always capitalized as a mark of respect. Then the snow begins to melt before the frost is out of the ground; and the earth, while still frozen below the surface, cannot absorb the water resulting from two to five feet of melting snow. During such periods tractors are virtually essential to all movement and all transport. Leduc and other Canadian oil fields occur in regions of black, bottomless gumbo, similar but perhaps deeper than the muckiest black lands of the Gulf Coast. Redwater, the latest field to be proven, is in an area of fluffy, black, sandy soil. Worse than the deep black soils are the muskeg areas of glacial drift. "We slip, slide, and skid around," said a tool pusher in discussing operations during April and May.

The low-pressure boiler is an important item in all Winter operations.

The low-pressure steam boiler is also an essential feature of winter production operations; but the production men, being organized on a permanent basis, have an easier situation than the well drillers. All gas separators, flow lines, flow tanks, and tanks of all sorts, are protected by steam coils; and gas lines, flow lines, fuel and water lines, etc., are customarily paralleled by two protecting steam lines laid beside them in the same ditch. By means of steam coils, crude is heated to a temperature of 60° F. for delivery to the pipe line. Indeed, all oil is warmed to this standard temperature for handling, in order to protect pumps, lines, and equipment from damage by low temperatures or by contraction and expansion. Oil comes out of the ground at a temperature of around 40° F. at Leduc.

Tank battery under construction. Note boiler already on the ground.

Pumping units are enclosed in individual, heated houses.

Extricating truck after breaking through ice on Saskatchewan River.

TRINIDAD EXPANSION

Threatened by Higher Costs

By GEORGE O. IVES
International Editor

TRINIDAD'S oil producers can look toward an increase in royalty payments early in 1949. With this increase, plus higher labor and material costs, and considering Trinidad's comparatively low return in crude oil per new well drilled, concern is being felt as to whether expansion of exploratory activity would be justified in view of an almost certain cut in over-all profits from producing properties.

Although the matter of royalty payments is still in abeyance, the government has served notice that in view of current higher prices for crude petroleum throughout the world, the present system by which companies purchase the royalty oil will be terminated in April. For the past two years the government has elected to take its 10 percent of the oil in kind, selling it back to the companies at a fixed price per unit of measurement. Since 1934, royalty payments had been simply on the basis of a fixed sum per ton of oil.

The new formula, and the one which will probably be invoked early in 1949, will give the government a royalty of 10 percent of the valuee of the oil, at field storage, the value being calculated on the basis of certain quoted world prices. Its net result would be an increase in the amount of money paid the government with consequent increase in per-barrel cost of production. The formula has been incorporated in a recent amendment to the Land Regulations, under which the oil industry operates.

A further cause for concern on the part of Trinidad oil operators is that reports of the big profits which accrue to many oil companies may divert attention of many political observers from the heavy financial risks assumed by the companies. Already there have been frequent efforts made by political groups to increase taxation of the industry. As one of the island's principal sources of exchange, petroleum has become the target of elements which would like to see the local government obtain more revenue from it.

Responsible representatives of the oil industry are taking the stand that additional burdens in the form of direct levies upon production will have harmful effect on the long-range outlook for expansion. They point out the necessary lag in time between beginning of exploratory activity to replace produced reserves and the actual discovery and development of new reserves. This is of particular significance in an area such as Trinidad, where possible petroliferous areas are comparatively limited, and it has been necessary to drill successively deeper horizons to replace depleted deposits.

May Discourage Capital

All of these factors, they say, will tend to discourage venture capital which does so much to support the operating branches of the industry in view of the higher costs and relatively great risks in exploratory operations which would reduce substantially the probable margin of profit. The rate of income tax had been raised during 1947 and was applicable during 1948, and the pressure now being applied is for still further taxation. At the beginning of 1948 taxes on income of oil companies had already been increased an additional 5 percent, bringing the income tax alone to 45 percent. Under the new royalty setup, payments per barrel will be nearly four times the 8-cent per barrel rate specified under the 1934 regulations.

According to a recent report by the Mines Department, proved reserves of crude in Trinidad were only 250 million barrels at the beginning of 1948, representing a supply at current rates of production of no more than 12 years or so. The success of stepout and semi-exploratory drilling during the year is thought to have been such as to at least maintain the reserve position. However, these additions have been in the form of expansion of previously proved fields rather than in the discovery of entirely new fields. Such new production as was found has not yet been evaluated, although one of them, south of the Barrackpore-Wilson field, in the Clarke Road area, may prove of substantial value. The greater part of the expansion of proved fields has been in the Penal region, where a considerable area was added to the west of previous field limits.

Operators as well as local oil administrative officials are unanimous in the contention that the maintenance of the colony's oil economy at its present level

TRINIDAD'S PRODUCERS, operating within restricted areas which materially reduce chances for discovery of new reserves, are faced with the necessity of finding these new reserves at materially increased physical costs, but feel still greater concern over the increased unit costs forced by substantial increases in royalty payments and income taxes. They are presently confronted with steady pressure from political sources for still greater taxation.

hinges on the discovery of new reserves. As previously pointed out, the exploratory campaign was cut back drastically by World War II material shortages which forced abandonment of wildcat drilling in favor of development drilling in order to assure production of essential crude for the steel expended. Such a program has resulted in the companies being several years behind in their oil-finding efforts. They are entering into the exploration program, but restricted areas make the returns none too attractive when compared to some other areas in the world. During the war, dry hole drilling had dropped to only about 4 percent of total wells drilled. Immediately prior to the war the percentage of failures had amounted to nearly 17 percent. Since 1945, failures have again risen to about 10 percent of total drilling. Additional need of new fields is pointed up by the diminishing return of the wells drilled in proven areas, where the greater number of inside wells as compared with outside wells shows less production per well since many interspaced wells are being drilled into reservoirs which have already shown pressure declines due to previous exploitation.

Deep wildcat near Southern Main Road Explores for new producing areas.

Offshore Operations

Despite the interest shown by Trinidad oil operators during the past several years in the possibility of developing offshore production in the Gulf of Paria, the situation remains at a virtual standstill due to the fact that no concessions have been validated.

Most producers had applied for licenses covering substantial acreage in shallow offshore waters, some applications dating back more than three years, but granting of formal permits by the crown has been held up pending decisions as to royalties, bonus payments, etc. For the most part the companies have held that royalties desired by the government would be excessive in view of the costly nature of operations. Meantime, a considerable amount of exploratory work has been done, including gravity meter surveys. One of the original plans had been for several of the substantial firms to drill the first offshore well as a cooperative venture, but several of them are now planning independent work when concessions shall have been granted.

Many producers such as the 35-year-old well in the background could not survive tax and royalty increases.

Much hope is held out for the marine areas, since the greater portion of Trinidad's production is now concentrated in an area relatively near the Gulf, and some fields produce right up to the shoreline.

In the Clarke Road area, Trinidad Leaseholds, Ltd., has drilled a deep wildcat which may be of considerable importance. A sand section 250 feet thick was found at 10,040 feet. Due to mechanical difficulties it was only possible to take in the top 100 feet of sand in the original completion, but such a sand body, over any considerable area, would be of extreme importance to Trinidad. While it is yet too early to determine the limits of the new field, the operators plan an active drilling program which should soon result in an evaluation of the area. However, it is not likely that development here will be as rapid as it might be in other areas of similar depth, since the extremely complex tectonics of this part of the island make for slow drilling with elaborate safety measures.

Elsewhere, exploratory drilling has brought rather negative results. In 1948 it had been thought that the Maloney area, north of the Guayaguayare fields of extreme Southeastern Trinidad, might be developed into an area of commercial possibility. Several shallow tests found some oil in thin sand sections, but the latest well, Maloney 3, was abandoned at 5438 feet after the several sands failed to show commercial oil. Another rig had been drilling the old Lizard Springs area without thus far expanding the area into important dimensions.

Cooperative Ventures

There seems to be a definite trend now toward cooperative exploratory ventures, with a division of the assumption of risk in new areas. In addition to the possibility of the first marine drilling being of that nature, the principal operators are teaming up for work in various land areas. During the year Trinidad Leaseholds and United British Oilfields of Trinidad (Shell Group) have been prospecting in the Naparima area without success. Three dry holes were drilled in the current program.

Observers have awaited with some interest the beginning of drilling by Trinidad Northern Areas Ltd., which is a partnership formed by Trinidad Leaseholds, UBOT and D'Arcy Exploration Company, Ltd. The three-company partnership had obtained permits for exploration in central Trinidad and other

areas, plus a substantial group of applications for marine acreage. A considerable amount of geological and geophysical work has been done, but no actual drilling has been started.

Trinidad Petroleum Development Company, which operates in the Coora, Los Bajos, Quarry and Point Fortin areas, has announced an extensive wildcatting campaign for southern Trinidad. Its plans include, among other things, a series of six exploratory wells in the Moruga area near the southern coast.

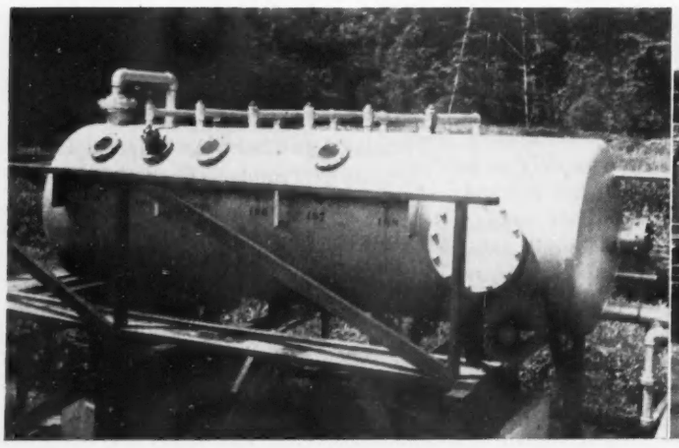
For a number of years certain Trinidad operators have been operating plants for the extraction of natural gasoline and distillates from gas, but the actual employment of gas in secondary recovery operations is comparatively recent. Reservoir conditions in most Trinidad fields had not been thought conducive to efficient repressuring and pressure maintenance operations, but experiments conducted over the past several years have shown that such work as has been done is of definite value, and the amount of gas being returned to reservoirs is increasing each year. Another net gain effected by gathering gas has been proved by one of the principal integrated companies which has started gathering and purchasing large quantities of gas for use in refinery operations, thereby releasing for export a substantial quantity of fuel oil that formerly had been used in the plant.

With the increase in gas use, including that returned to the reservoirs, has come an effort toward gas conservation. This trend toward fuller conservation has been responsible in some degree for slight decreases in output from some flowing wells. The operators are keeping a closer check on gas-oil ratios, and in many instances are cutting the wells back on smaller chokes to produce at more efficient ratios even though it results in somewhat smaller output. An increasing attention to bottom-hole pressures has also led to more shutin time for the wells during surveys of various areas. For several years Trinidad operators have been putting their gas to work in other ways. In addition to gas-lift and plunger-lift as a producing method, the gas collected in the high-pressure systems in some fields has been used in conjunction with automatic producing and metering operations.

Permanent living installations in Southwest Trinidad producing area.

1948 Production Up

While the figures on crude production for 1948 are not yet tabulated, it seems likely that there will be a very slight increase for the year over the 20,520,554 barrels produced in 1947. Some increases have been possible in areas such as Penal and Wilson, where there has been an upsurge of drilling, but these have been for the most part offset by declines in older areas. Under stress of emergency, a considerable increase could be effected in production, but it is unlikely, without discovery of important new fields, that production can be kept at a level higher than 57,000 to 58,000 barrels daily over any extended period. There has been a pronounced tendency to cut back on producing rates of flowing wells, as a conservation measure, and to preserve the backlog of flowing production and depend on artificial lift wells for a minimum of about 40 percent of the total output. From 1940 to 1945, production peaks were reached by drawing around 70 percent of the total from flowing wells at the expense of ultimate flowing life.



This device saves gas from stripper wells while automatically measuring production.

Field gathering station has automatic metering and pump-off system.

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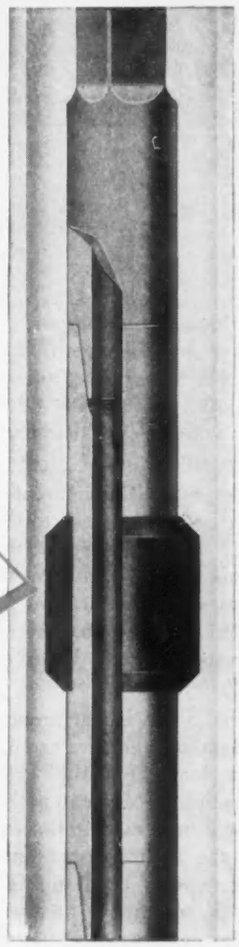
KELLY SUB STABILIZER



That all-important top joint of casing stays after the drilling contractor leaves the location. There is no need for it to be almost worn through from the beating the kelly gives it. Protect your surface casing with a Patterson-Ballagh Kelly Sub Stabilizer installed on a saver sub.

Typical reasons for kelly wobble are the rotary table not being centered immediately over the casing, the crown block and traveling block not lining up with the hole, and a slight kink in the kelly. With the kelly 20′ down, a slight amount of wobble will cause a corner of it to contact the side of casing and wear it through in a short time.

With a 4¼″ square kelly hanging in 9⅝″ casing, as shown in the illustration on the right, the distance between the side of the casing and the corner of the kelly is 1-21/32″. This is a small amount of clearance when you consider the number of causes that may make the kelly wobble. The cross section shown has a 4¼″ Kelly Sub, 6″ O.D., grooved to 5½″, with a Patterson-Ballagh Stabilizer, Code: FLAX, installed. The 7-7/16″ diameter of this stabilizer gives ample protection against wear and does not interfere with mud circulation. Install a Patterson-Ballagh Kelly Sub Stabilizer on your saver sub *today* and save your surface casing.

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House Committee URGES AID FOR Mexican Oil

One of Mexico's most recent refinery installations.

THE long-awaited report of the House Interstate and Foreign Commerce Committee (Wolverton Committee) on a U. S. policy toward the development of Mexico's petroleum resources contains two key suggestions:

1. The State Department is urged to use its good offices to consummate pending deals between the Mexican government and private American oil companies for exploration and development "to the end that Mexico's petroleum resources may become proved reserves."

2. The State Department and appropriate lending agencies are urged to consider a loan "for the expansion and construction of Mexican petroleum facilities, including such items as an oil line across the isthmus, gas lines into consuming centers both in Mexico and in the U. S., a refinery on the west coast, and other aspects of the program."

The proposals are not recommendations as such on the part of the committee, but are indirect proposals to the State Department for its consideration.

The Committee's suggestions received a cool reception in many sectors of the industry, and even certain officials in the State Department were doubtful as to how far department assistance should go, until Mexico liberalizes her petroleum laws. The general industry feeling was that a loan to Mexico would accomplish little until a sounder understanding had been worked out between the Mexican state oil monopoly (Pemex) and prospective American oil operators.

The committee did qualify its proposal with the proviso that any financial assistance should be made available in the form of serial credits "with disbursements subject to a joint commission and U. S. disbursing agent, and with full serial reports concerning the use of the funds for the purposes allocated."

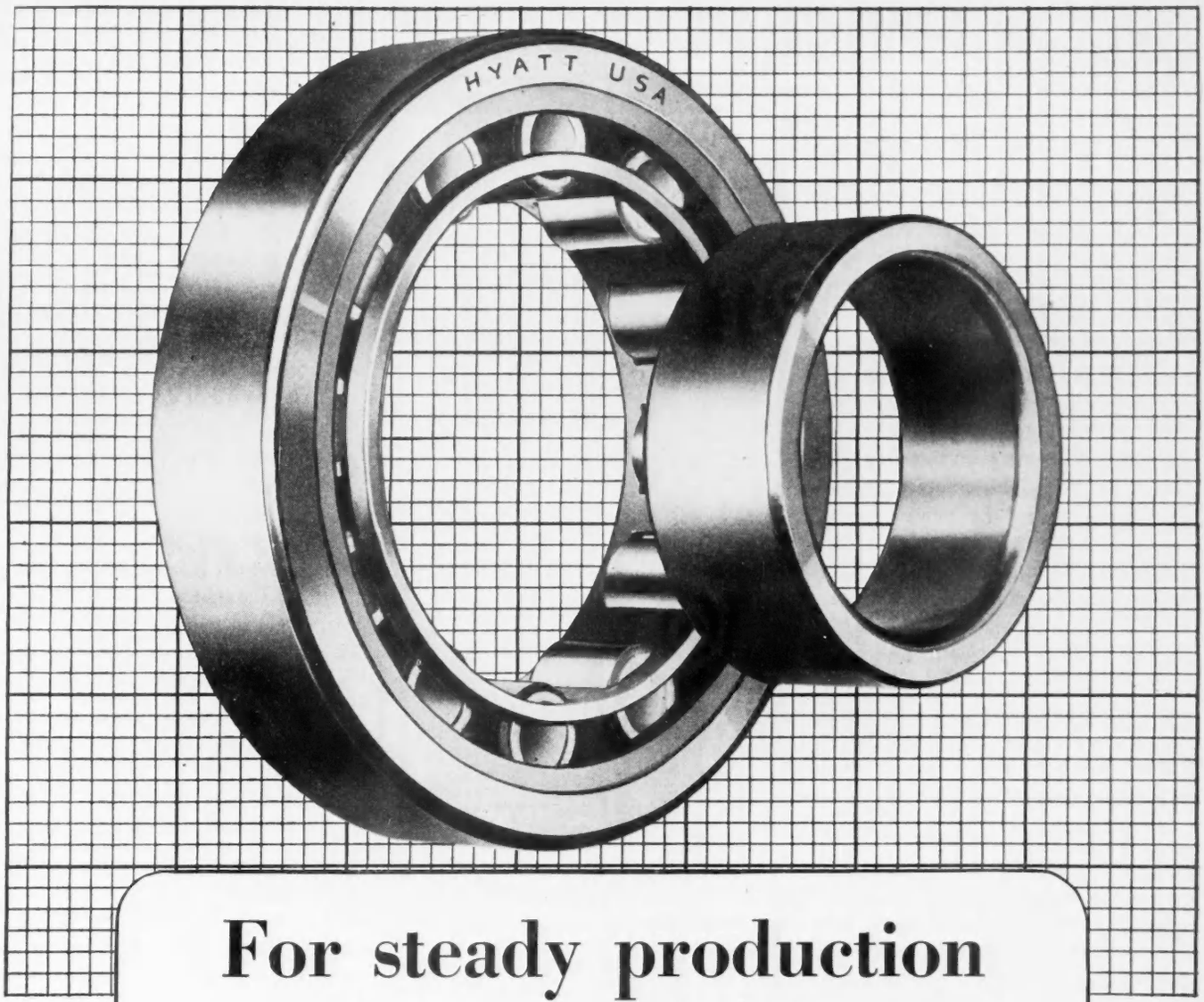
The committee did not indicate the amount of the loan it deemed proper or adequate, but from other sources it is learned that a number of committee members have been thinking of a grant of about $45 million.

How far apart Pemex is thinking from demands of prospective American operators is indicated in the committee's explanation of Mexico's current stand on the re-entry of American capital and skills into her petroleum industry. Fifteen members of the committee visited Mexico in August and September and discussed with Pemex officials the way in which American private companies might engage in work in Mexico and be compensated therefor. The committee reveals the conditions set forth by Pemex in the following words:

"The proposal basically was that within the existing law (1) private companies, acting in effect, as agents for Pemex would operate on sites satisfactory to them and would perform the requisite geophysical and other exploration, and would engage in exploratory drilling; (2) after discovering petroleum, the companies would either surrender operations to Pemex or operate as agents for Pemex; (3) the companies would be reimbursed for capital expenditure out of 50 percent of the gross production with no deduction for expenses, and the companies would be compensated for their efforts and risk out of 13½ percent of the gross production, without deduction for expenses, such 13½ percent being net over all taxes or any other charges whatsoever; and (4) the companies would have an option on the remaining petroleum beyond the necessary requirements of the Mexican economy."

The committee report says that the committee itself discussed with "a number of interested oil companies" the bases on which these companies would consider a working arrangement with Mexico, "and it was evident in some of the conferences that some of the oil company negotiations were being conducted along the revised lines."

Shot-hole drilling in active northeast Mexico region.



For steady production team up with Hyatts

WHEN continuous operation is essential to profitable production, little things such as Hyatt Roller Bearings make an important contribution.

Drilling and pumping units equipped with Hyatts are noted for their steady, carefree performance. By preventing excessive wear, Hyatts prolong the life of wrist pins, shafts, gears and motors.

Leading manufacturers, for years, have built Hyatts into their equipment and operators have learned by experience that Hyatts are consistently dependable regardless of weather and working conditions.

Team up with Hyatts—specify them for the next equipment you buy. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

When Well Conditions Demand

NOT only does the Baker Model "D" Retainer Production Packer take care of the "every day," simple installations, but it is adaptable to many of those previously difficult or impossible applications.

This is due first to the construction of the Packer itself, employing two sets of opposing slips, with a Hycar packing element between them, so that the Packer virtually becomes a part of the casing, cannot be moved up or down the casing, and prevents fluid or gas from passing between the packing element and the casing. When the Setting Tool, used to set the Packer, is removed from the well, only the smooth-bore Packer is left in the well, securely packed-off, and ready for selection and use of the proper Baker Packer Accessory Equipment to meet production requirements.

ACCESSORY EQUIPMENT IMPORTANT

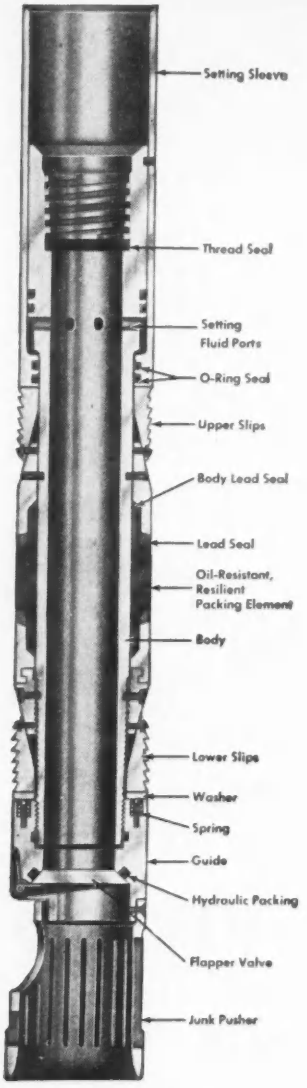
It is the complete line of Accessory Equipment that is responsible for the outstanding adaptability of Baker Packer installations to produce one or more zones, simultaneously or separately—through tubing or casing—and often with flexibility to permit production changes without pulling the tubing string.

One interesting and useful accessory unit is the Baker Tubing Seal Nipple, Multi-V Type (Product No. 448-D) which is an important element in many Packer installations to effect a fluid-tight seal in the annulus between the tubing string and the internal smooth bore of the Packer. This unit permits movement of the tubing string, either up or down, over the length of the Packer bore; and, for additional movement more than one Multi-V Tubing Seal Nipple may be used, as shown in Figure 1 on the opposite page.

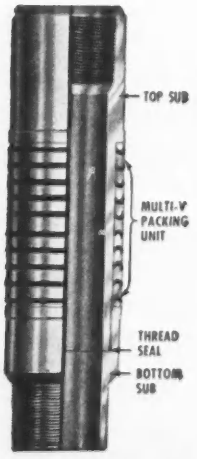
CONVENIENT LATCHING SUB

The Baker No Left Turn Latching Sub (Product No. 473) is positioned in the tubing string just above the Tubing Seal Nipple. This ingenious device does not effect a seal, but provides a quick-engaging, positive hold-down for the tubing production string, and holds the Tubing Seal Nipple in proper position in bore of Packer where it cannot be moved upward or downward by expansion or contraction of the tubing string.

Inasmuch as no "set-down" weight is required for operation of this Sub, the tubing can be suspended in tension, if desired, so that pressure bombs (and other devices) may be dropped readily through the tubing. Operations are not handicapped by "corkscrewed" tubing which often results when set-down weight is applied to conventional type packers.



Baker Model "D" Retainer Production Packer Product No. 415-D



BAKER TUBING SEAL NIPPLE, MULTI-V TYPE, which effects a fluid-tight seal between the tubing string and the bore of the Packer.

APPLICATIONS ARE MANY AND VARIED

In addition to the fact that the Baker Model "D" Retainer Production Packer is used for single-zone or multiple-zone production applications, it is ideal for isolating casing, for salt water disposal, for acidizing, re-pressuring, and many other applications.

Other features which appeal to veteran production men are its Complete Drillability—Resistance to High Temperatures—Corrosion-Resistant Construction—Freedom of the Tubing from the Packer—and Positive Anchoring Against Upward or Downward Movement.

Descriptions, illustrations and specifications are in your 1948 Baker (or Composite) Catalog; a new brochure covering the Baker Retainer Production Packer will soon be off the press ready to mail at your request; and Baker representatives in every active area are anxious to serve you.

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A PRODUCTION PACKER

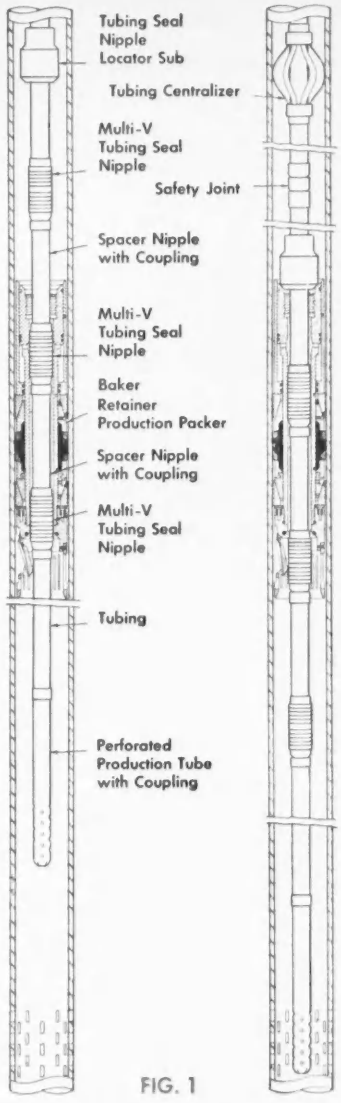


FIG. 1

FIGURE 1—(left)

This single-zone installation is recommended where it is necessary to compensate for variations in the length of the tubing string, and to prevent excessive weight being imposed upon top of Packer when extreme increases in bottom hole temperatures cause expansion of tubing.

Three Baker Tubing Seal Nipples, Multi-V Type, are used, and spaced so that one Nipple is always sealed off in the bore of the Packer. The desired length of the tubing string is determined, to permit proper spacing of the Multi-V Nipples in the Packer and allow for proper connection at the tubing head. The tubing string is run into the well until the Baker Locator Sub contacts the top of the Retainer Production Packer. The tubing is then raised to remove the Seals from the Packer, to permit circulating and unloading the mud from the well. When the well has been unloaded, the tubing is set down and the final Christmas tree connections made.

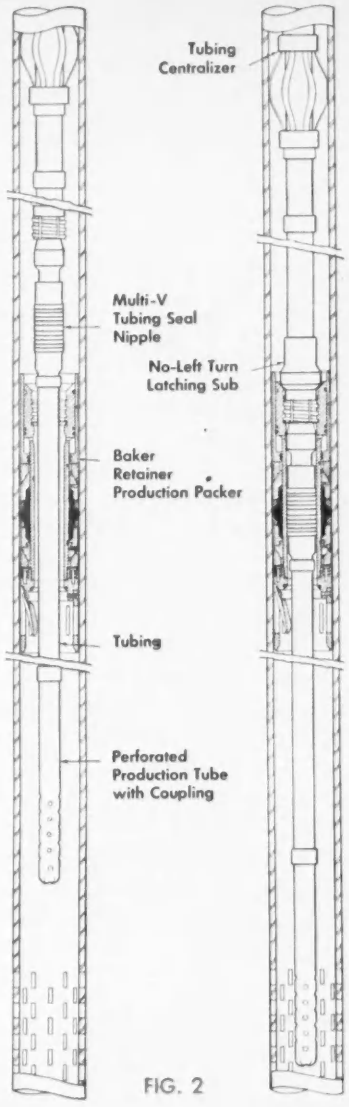


FIG. 2

FIGURE 2—(center)

This hook-up is for producing a single zone with the production string anchored to the Packer, an advantageous feature when it is desired to: (a) produce the zone by pumping, while keeping the production string in tension; or (b) produce the zone by flowing without having to impose excessive weight on the Packer in order to hold the Tubing Seal Nipple properly positioned in the Packer bore; or (c) high pressure injection of gas or fluid for re-pressuring or secondary recovery.

The production string is run in the casing until the No Left Turn Latching Sub rests on top of the Packer. This is indicated at the surface by a drop in weight recorded on the strain indicator or the weight indicator. The production string is then raised approximately five feet, and in this position the zone may be washed and brought in, if it will flow.

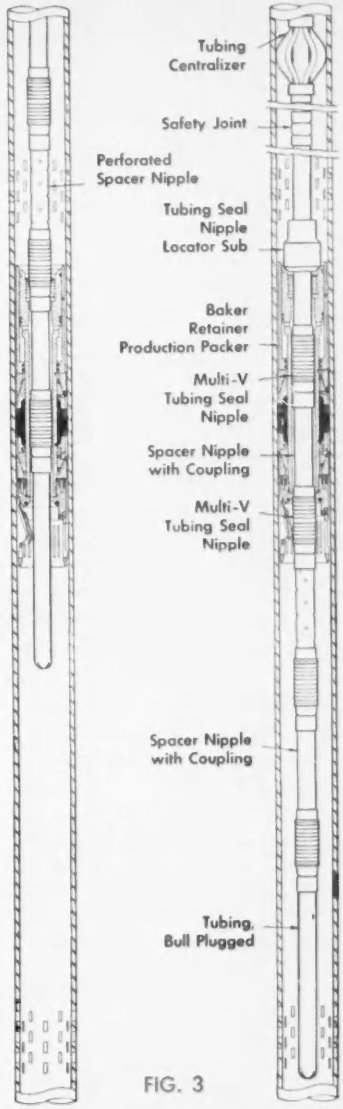


FIG. 3

FIGURE 3—(right)

This two-zone hook-up permits washing the upper zone and unloading the annulus; or the upper zone may be killed through the tubing without running a side door choke on a wire line. The casing head used must pack off while the tubing is being raised or lowered. The Packer is set close below the upper zone, and the production string (made up as shown in Figure 3) is run in until the Locator Sub rests on top of the Packer, indicated by a drop in recorded weight on the strain indicator.

To wash the upper zone, or to unload the annulus, the string is raised about 8 feet to bring the Perforated Spacer Nipple above the Packer, but with the lower Tubing Seal Nipple inside the Packer bore. After the upper zone is brought on production through the casing annulus, the production string is lowered until the Locator Sub rests on top of the Packer. Weight of 10,000 pounds, or more if desired, may be set on the Packer, and the lower zone brought in through the tubing, by swabbing if necessary. To kill the well later, the lower zone is killed through the tubing; the production string raised (left view) and the upper zone killed. The production string is the removed from the casing.

Demand a BAKER Model "D"

The report concedes that "some of the domestic companies believe that unless there is a change in the Mexican petroleum law, any contract with Pemex rests on a very shaky legal basis."

"Some companies," the report continues, "appear not to find the same legal difficulties in working within the framework of the existing (Mexican) petroleum law, but feel that the extent of supervisory direction by Pemex . . . was objectionable. Others indicated they were reluctant to surrender operations to Pemex after petroleum was discovered and secure reimbursement or compensation out of the net income (i.e., gross production less pro rata expenses) obtaining under Pemex management.

"All companies felt that the reimbursement and compensation terms of the 80-20 proposal (an earlier Mexico offer) were inadequate for the risk involved. Companies which had had further negotiations last fall along the lines of the proposal which Pemex discussed with the committee last September, apparently had no difficulty with the amortization of investment provision nor with the suggested change in compensation to a percentage of gross production rather than of net income. Their only question was one of adequacy of the 13½ percent rate as compensation for the risk involved."

Construction on pipe line project in Tampico region.

Varying Reception

The committee reports that "some oil companies and Pemex are close enough in their negotiations that they seem to be within the area of possible eventual agreement, while other oil companies do not seem to find the terms of the proposed arrangements sufficiently attractive to elicit their participation."

The report makes passing reference to a comparison of current arrangements in Venezuela with the proposed Mexican offer. "In Venezuela the government and the companies presumably share on a 50-50 basis in the net income (arising after all expenses including adequate amortization charges for capital invested). In actual practice it appears that for some companies a division of net currently is 55 percent for Venezuela and 45 percent for the companies with the Venezuelan government further receiving substantial indirect reimbursement, in the form of heavy expenditures for schools, roads, housing, hospitals and other 'social' benefits estimated by one company as equivalent to approximately one-half of the entire payroll expense.

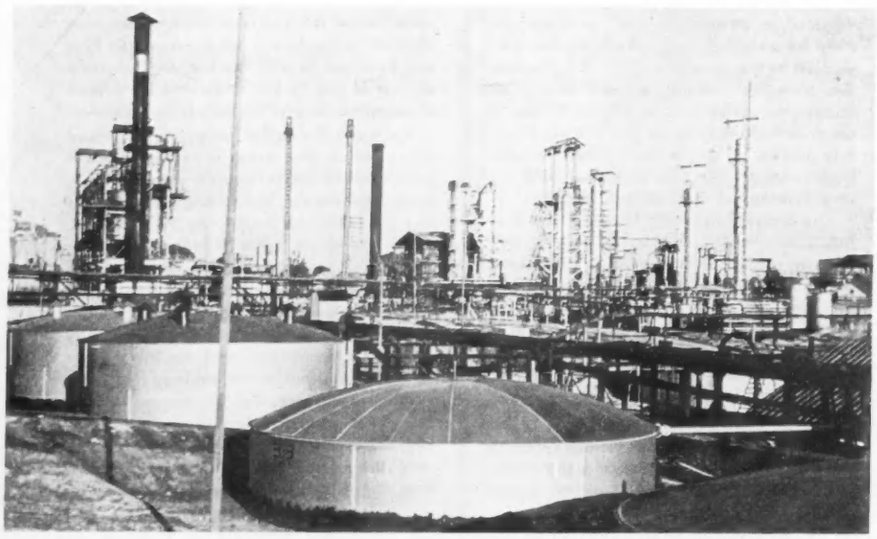
"The committee has not made detailed calculations of the differences between the so-called 50 percent of net income arrangement prevailing in Venezuela and the 13½ percent gross production suggested by Pemex, but one oil representative intimated that the latter figure calculated as about the equivalent of 35 percent of net income and that a 16 percent of gross production figure would approach some 45 percent of net income."

The report further assures Pemex officials promise that Mexico's oil program does not intend to exclude the participation of American capital, and they felt the competition they would be afforded would be beneficial to Pemex.

The committee approached its study of Mexican oil from two focal standpoints: (1) military needs; (2) improved economic relations between Mexico and the U. S.. The report points out that the export of U. S. commodities to Mexico represents a trade of about $½ billion yearly, "which ultimately, of course, can be financed only by Mexico's having a substantial export trade. It seems clear that the only way in which our business men can expect to continue such substantial exports to Mexico is through that country's developing an exportable petroleum surplus.

"Of even more significance in the disturbed times of today are considerations of national defense and the position of the U. S. in the event of an emergency. It appears clear that not only must we have reasonable assurance of the continuation of supply from present sources, but we must have additional sources available for pyramided emergency demand."

The committee adds that all these considerations "point up the importance of Mexico as a potential source of supply, inasmuch as there seems to be no disagreement whatever that Mexico possesses potentially large reserves."



Minatitlan refinery in the Tehuantepec Isthmus area.

South America's Problems

First completed jetty at Shell refinery, Cardon, Paraguana.

By HENRY OZANNE
Staff Writer

DEVELOPMENT of South America's petroleum resources is suffering an unexpected setback from two causes, one economic and the other political.

The economic reason is the recent weaking of the world oil markets. The political factor is the new U. S. policy discouraging oil development loans to countries that are moving toward nationalization of their petroleum industries.

Economically, crude production in Venezuela is being cut back sharply because of the more favorable world supply situation. Such reductions reverse the upward trend in production that had been uninterrupted since 1941. Creole Petroleum Corporation, largest Venezuela producer, reduced its December, 1948, output by 40,000 barrels daily under its November, 1948, level. Creole produces nearly one-half of all Venezuela's oil. Shell, second largest operator in Venezuela, allowed its option on royalty oil to lapse by declining to pay the premium price, and other producers are expected to follow suit. More than six months ago Venezuelan government oil officials indicated their desire to hold production at more conservative levels in the interest of a stable economy.

Politically, few South American nations now qualify for loans from U. S. lending agencies in connection with once-proposed oil expansion programs. The new policy was first enunciated at the Conference of Foreign Service Economic Officers at Rio de Janeiro, where it was pointed out that nationalization policies are presently the greatest deterrent to further development of potential South American oil fields.

Bolivian Loan

Bolivia at present is the only South American nation carrying a U. S. loan for petroleum development. Bolivia obtained an $8½ million line of credit from the Export-Import Bank toward her $15½ million oil program, the key project of which is the Y-pipe line from the Camiri fields, in South Central Bolivia, to Sucre and Cochabamba, where refineries will be built. The line will have a split-off point at Zudanez.

The Bolivian loan was approved before the new U. S. policy was defined, and under existing conditions it is certain that Bolivia could not secure such credit since she expropriated Standard Oil Company (N. J.) properties in 1937. Thereafter Bolivia set up a state oil agency, Yacimientos Petroliferos Fiscales Bolivianos, that is currently producing 30 percent of the country's crude requirements. The rest is imported and obtained from International Petroleum, an affiliate of Standard Oil Company (N. J.).

YPFB authorities are projecting a stepped-up drilling program of 25 wells but may find that plan stymied because of inability to raise the needed $24 million loan. Bolivia's program is designed to make her self-sufficient in oil, and the pipe line project, it is said, will enable her to be 85 percent self-sufficient in all petroleum products by early 1950. Industry experts believe the estimate is far too optimistic.

In Paraguay a partial nationalization program covering oil has been proposed by President J. Natalicio Gonzalez. Union Oil Company of California, through its subsidiary Union Oil Paraguay, is the only operator in the country and so far has failed to find oil despite an expenditure of several million dollars in exploration work. It is felt that Paraguay will not push its nationalization plans for the moment, since such a program might discourage Union to the point of withdrawing, and might even cause Jersey Standard, now importing and distributing about 8200 barrels a day, to divert its supplies outside the country. At the moment Paraguay is in dire need of petroleum products. Gasoline prices there are among the highest on the entire southern continent.

The outlook is somewhat more encouraging in Chile where American contractors working with the government have discovered eight producing wells and four gas wells in the Cerro Manantiales field of Tierra del Fuego. Chile's president, Gabriel Gonzalez Videla, is friendly

Road construction in Bolivia at Sanandita.

to foreign operators and has declared that after Chile's own oil needs are satisfied, the country's whole exportable surplus will go to the U. S. However, Chile may be handicapped in a vigorous development of her oil reserves by a lack of capital which may be barred to her in the form of U. S. loans because of the role of her government in industry.

In Argentina the picture is less favorable. Crude production has been rising, especially government production which accounts for 72 percent of all Argentinian output as against 70 percent in 1947. But Argentina is still 60 percent short of her total petroleum requirements and estimates that $160 million will be needed merely for oil imports in 1949. Argentina's economic czar, Miguel Miranda, is not particularly friendly to the American petroleum industry and is seeking to barter Argentina coal for European oil.

Brazil's crude oil development is now reaching the point where it would be possible to draw as much as 2000 barrels a day from the Bahia fields. This would still be far below the country's requirements, but exploration and wildcatting outside of the Bahia fields has been negligible compared to the immense areas of territory. Although the administration as well as the nation's economists agree that opening the door to foreign capital is the quickest way to develop Brazil's petroleum resources, the strong nationalistic feeling which prevails has prevented any such action. The development of this important resource remains the responsibility of a government agency whose budget necessarily is limited to a mere fraction of the capital outlay required to prospect intensively throughout the country. Fast becoming industrialized, consumption of petroleum fuels and other products is rising by leaps and bounds, and it is unlikely that a local supply will be developed without the benefit of outside capital and technology.

A series of efforts to liberalize the policy has resulted in a constitutional amendment to make it possible to allow foreign capital to operate in Brazil. However, the all-important implementation of the amendment by adequate petroleum laws is still hanging fire. The first draft of such a law to be reported out of the legislature is still far from inviting to foreign investors, and even if enacted will fail to attract more than a fraction of the capital necessary. With increased availability of Middle East and Caribbean crudes, the possibility of ventures on a large scale into Brazil becomes even more remote.

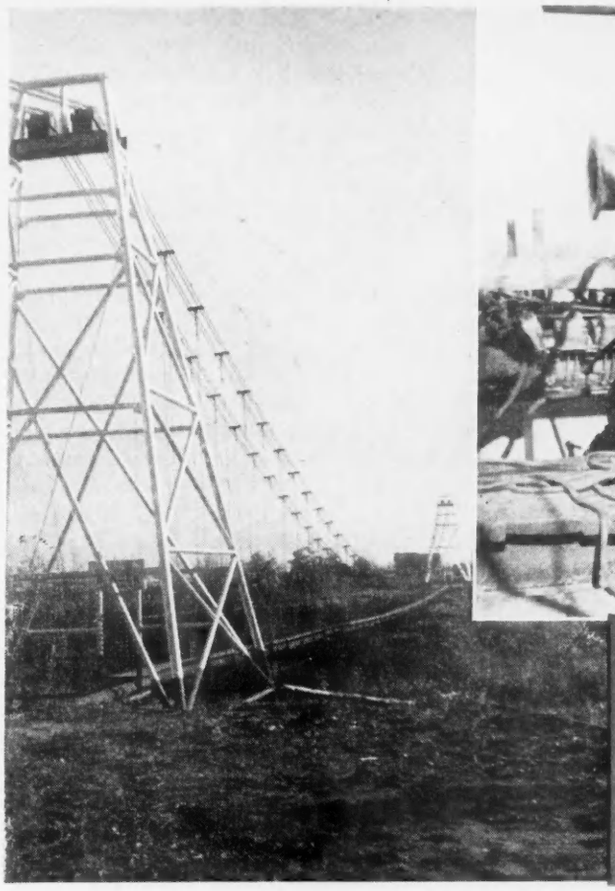
Uruguay an Importer

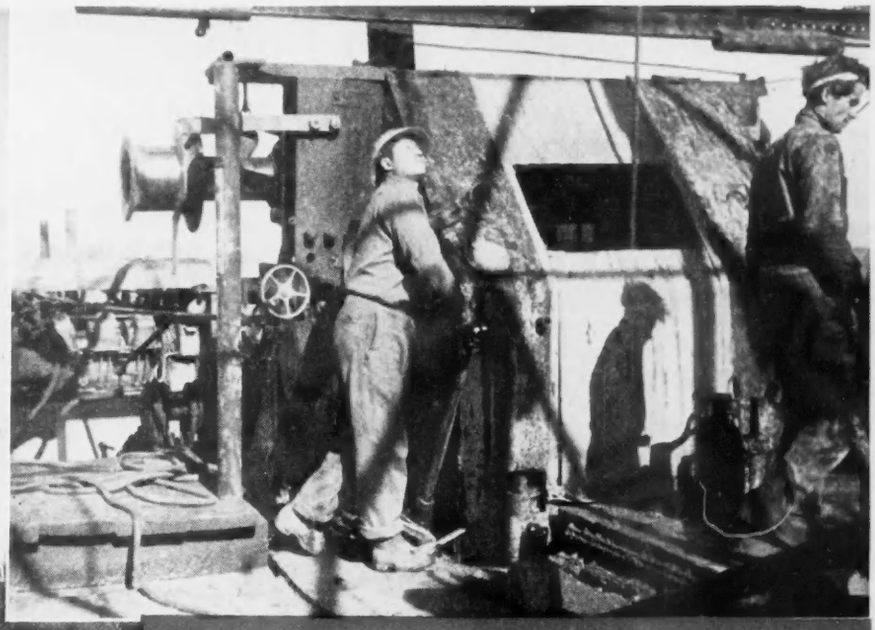
Uruguay, with a daily consumption of about 10,000 barrels of petroleum products daily, is another South American nation which is strictly an importer of crude oil. Most of the products are manufactured in the country at a modern refinery in Montevideo, but every barrel of crude must be imported. Under its nationalization policy there have been no discoveries of oil reserves.

Peru's petroleum economy is precariously balanced. Although it is still a net exporter of both crude and products, increased industrial and civilian consumption is climbing at an alarming rate when compared to the producing potential. Some slight increases in production were effected in 1948 over the 1947 rates, but this has been at the expense of drawing on previously discovered reserves rather than discovery of new sources. With great areas of promising territory yet unexplored, the political setup has been such as to block all efforts to obtain a liberalized policy in regard to foreign operators.

The urge of Peruvians to have its resources developed has survived several changes in administration, but opposing factions have not allowed enactment of adequate laws. Units of some of the world's largest petroleum firms have maintained organizations in Peru for years in anticipation of moves which would allow them to explore for oil with promise of realizing a return on their investment. An effort was made early in 1948 by the Bustamante regime to liberalize the policy by Supreme Decree after other means had failed. However, it was not possible to convince prospective investors of millions of dollars that they would be satisfactorily protected under such a decree. Now most of the major companies have withdrawn their representatives. While crude was in extremely tight supply the hazards of expensive exploration were thought to be justified. The current combination of a softer market and a hostile policy have caused a lessening of interest in the "long shots."

With Peru, Colombia, Ecuador and Venezuela the only oil-exporting countries in South America, the continent's petroleum economy is not well balanced, and the oil programs in other countries of the continent are important both for their own domestic needs and for a continental equilibrium. That whole program which as recently as three years ago appeared promising and significant, is now fast being placed on the shelf as unlikely of realization in the near future.





Western Canada Has Banner Year

LEFT: Imperial Oil Pipe Line Company's creek bed crossing near Leduc.
RIGHT: Rig on Imperial's Leduc 109. Driller is A. J. Gladstone.

By C. O. NICKLE
Staff Correspondent

THE CANADIAN oil industry looks back on 1948 as "the year by far the greatest, on every count, in the half-century history of the search for oil and gas in the West." With equal confidence the industry can look forward to 1949 and say "Canada has only seen the beginning. The new year should dwarf the efforts, and the results, of the past."

During 1948 Alberta and the rest of Western Canada became a focal point of world interest, for the efforts of explorers brought results that materially altered world thinking on sources of oil supply for the years of increasing demand ahead.

During 1948 prairie oil production climbed by 62 percent, recording a 4.6 million barrel increase to 11.95 million barrels compared with 7.34 million barrels in 1947. The past year brought out far more oil than ever before in Canadian history. This year will set another record, far ahead of '48.

For Alberta and Saskatchewan consumers, 1948 brought a goodly share of the fruits of oil discovery. Gasoline, tractor fuel and other products prices dropped early in December, as Alberta crude, processed in Imperial Oil Ltd.'s new Edmonton refinery, and at existing plants in Saskatchewan, moved outward to displace higher-cost U. S. petroleum. The price cut was the first major break in the world-wide upward spiraling of petroleum prices following the war. Prairie consumers will save upwards of $9 million yearly from the price cut. The future will probably bring further and more widespread reductions as production increases, markets broaden and low-cost pipe line transportation come.

DISCOVERY of at least two additional major fields, and expansion of older fields, including the development of Leduc into one of the important oil sources of the continent, has focused attention on Western Canada as a region of tremendous potentiality. Observers feel that developments of the past two years fully justify the great investments already made, and planned for the immediate future.

Alberta's government, as custodian for the province's citizens, started to reap the harvest in 1948. The fiscal year will bring it a return of considerably more than $5 million from lease and reservation fees, bonuses on crown oil reserves, and royalties from production. Last year the return was only $1,635,000, while 1946 brought only $900,000. The year ahead is expected to bring a return dwarfing the record of 1948. Other western provinces, of which only Saskatchewan has yet found production, have made a small start on a harvest from lease and reservation fees.

Increased Exploration

Into Alberta, whose plains and foothills have yielded Canada's only major oil and gas discoveries to date, poured the great bulk of the estimated $50 million spent in 1948. Into Alberta will go the bulk of the anticipated $100 million of 1949 spending, but there is also growing recognition of the possibilities of

British Columbia, Saskatchewan, Manitoba and the Northwest Territories, and these regions will not be neglected.

Last year saw the taking up and commencement of exploration on far more millions of acres than ever before. By year's end more than 56 million acres of government and private oil rights in the prairie provinces were under exploration commitment or lease, nor far short of double a year ago. More than 44 million acres of the total are in Alberta, but only a fraction of the prospective oil and gas territory in that province and its neighbors has so far been scratched. This year will bring more detailed exploration of the lands now committed, and will see extension of activity to many more millions of acres.

Seismograph and gravity meter crews triple the number of any previous year, and more geological parties than ever before, looked for structures from Manitoba to British Columbia, and from the American border far into Canada's northwest. By year's end geophysical crews exceeded 65, compared with a peak of 22 in 1947.

Following up the geological and geophysical parties on exploration, and following up discoveries on development, more and more drilling rigs went to work. By year's end the total topped 80, compared with 50 in use a year ago, only 20 two years ago. The number will further increase in 1949.

Drilling rigs made hole at double the rate of 1947. In Alberta, where more than 95 percent of 1948 drilling was centered, more than 1,700,000 feet of holes were drilled in search of oil or gas. In 1947 the total was 882,000 feet, while in 1946 only 402,000 feet were drilled. The year ahead will set a new record. During 1948 an estimated 366 wells completed in Alberta, including 210 oil wells, 23 gas wells and 133 dry holes.

Recent Discoveries

The past year brought concrete results, a long list of oil and gas discoveries and field extensions. Top-ranking was Imperial Oil's Redwater discovery three months ago. Based on only half a dozen completions by year's end, Redwater bids fair to become one of the world's biggest single oil strikes of 1948. Estimates of oil reserves range beyond 500 million barrels. Redwater will become a major factor in Canadian oil supply in 1949.

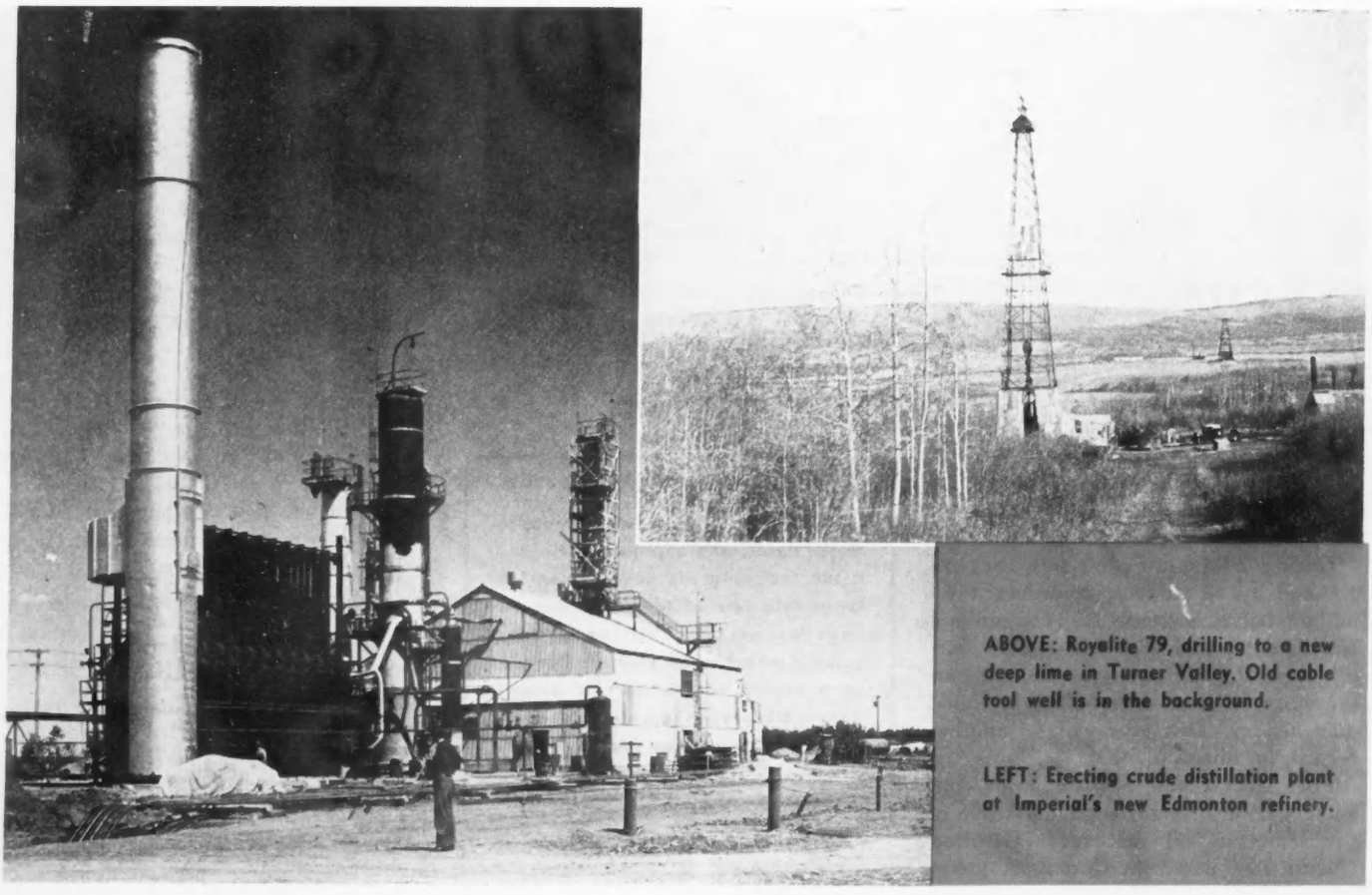
Imperial's Leduc discovery . . . the major find which started the western oil boom in 1947 . . . became a reserve estimated at 200 million barrels of oil and more than 500 billion cubic feet of gas during 1948. Its boundaries were spread wide by Imperial's oil strike a township north at Woodbend, and by the extension efforts of such independents as Globe, Leduc West, Okalta, Home, East Leduc, Central Leduc and Continental. The full limits have still to be determined. During 1948 the Leduc area poured out about 4.65 million barrels of oil.

In the southwest corner of Alberta, Canadian Gulf Oil Corporation completed its Pincher Creek discovery well early in 1948, a 2¼-mile deep well with estimated potential of 45 million cubic feet of gas and about 1500 barrels of light oil daily. This wet gas strike, which could mean the start of another major field of the Turner Valley type, is now being followed up by two more Gulf wells, and an answer should be obtained in 1948.

The Hanna-Craigmyle area popped into the limelight late in the year with completion of Hanna Petroleum's discovery oil well with initial production of 360 barrels daily, and a drill-stem test at Socony-Vacuum Oil Company's Craigmyle venture which showed a very substantial oil flow.

The Lloydminster region, which started blooming as a "heavy crude" oil field in 1947, jumped its 1948 production to around 1.6 million barrels, about double the previous year, as independents speeded development of what has become Canada's leading black oil reserve.

Elsewhere in Alberta during 1948



ABOVE: Royalite 79, drilling to a new deep lime in Turner Valley. Old cable tool well is in the background.

LEFT: Erecting crude distillation plant at Imperial's new Edmonton refinery.

Baash-Ross News

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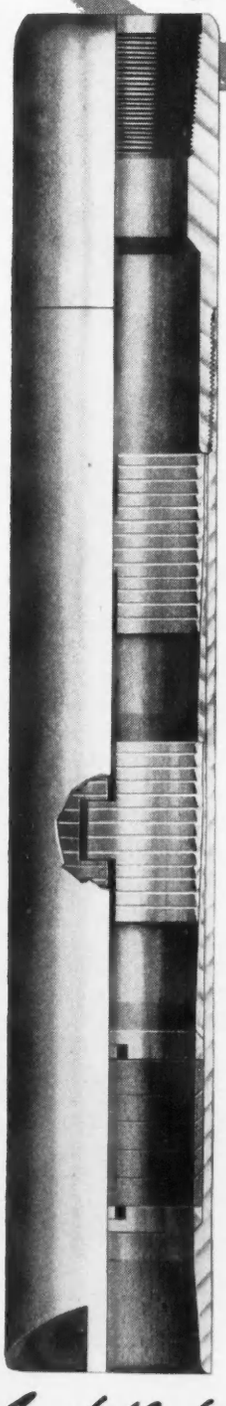
OUR 28th YEAR

Here's the tool for SIMPLE-POSITIVE-LEAKPROOF casing repairs

★ PRESSURE-TIGHT PACKING UNIT CANNOT EXTRUDE

★ DOES NOT REDUCE I.D. OF CASING STRING

★ DOES NOT DISTURB CASING CEMENT JOB

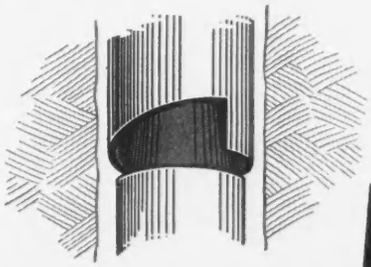


It's the BAASH-ROSS PACKING CASING BOWL

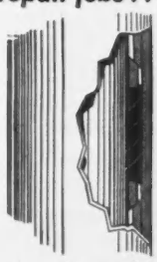
Repairing damaged or split casing strings is an easy, foolproof operation when you use this field-proven tool that has long been a dependable standby among leading operators throughout the world. It's the Baash-Ross Packing Casing Bowl—and it offers a number of important advantages on modern casing repair jobs . . .

Easy to Install!

Here's all you do to make a quick positive casing repair with the Baash-Ross Casing Bowl. First, cut the casing below the defective area (Baash-Ross makes a cutting tool that is ideal for this job!) and remove the upper portion of the string from the well. Discard the defective portion of the string, replace with good casing and attach a Packing Casing Bowl to the bottom of this replacement string. After the repaired casing string is run back into the well, it is lowered until the top of the casing standing in the hole passes completely into the Casing Bowl and seats against the shoulder in the upper portion of the Bowl.



Then the string is simply raised a short distance to set the slips and expand the lead packing to a permanent, pressure-tight fit against the casing in the well . . . the casing suspended at the surface in the usual manner to retain the tension . . . *and the job's done!*



FOOLPROOF PACKING ELEMENT

Note in the cutaway view of the Packing Casing Bowl how the upper and lower steel rings that retain the lead packing elements have a compressible joint like a piston ring. This permits them to close around the pipe along with the lead as it expands, thus preventing the lead from extruding out of the packing area. Result—a tight leakproof pack-off between the old and new casing sections, without need for cementing or other complicated sealing operations!

FULL INSIDE DIAMETER

Another important advantage is that the *minimum* inside diameter of the Baash-Ross Casing Bowl is equal to that of the Casing to which it is attached. Any tools, liners or other equipment that will pass through the casing string will also pass through the Casing Bowl without hanging up!

CEMENT JOB IS UNAFFECTED

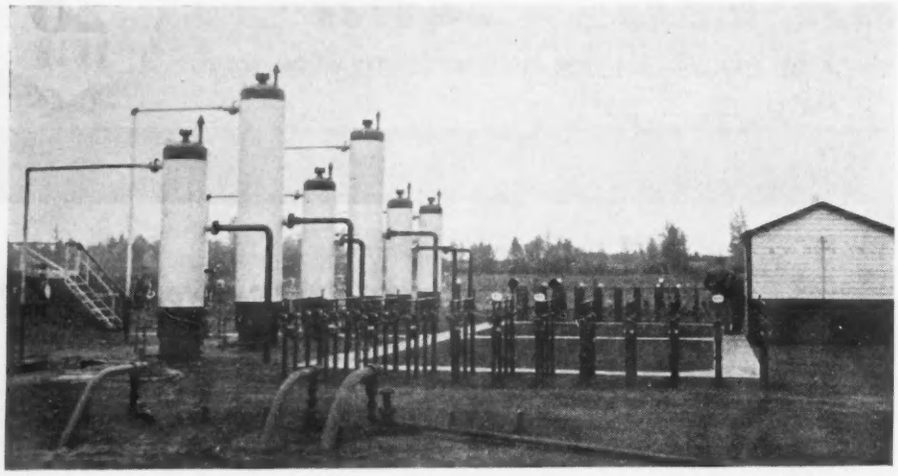
Since the Packing Casing Bowl attaches to the top of the casing standing in the hole, the cement shut-off around the shoe is not disturbed. This, coupled with the tight leakproof joint effected between the Casing Bowl and the casing in the hole, assures the repaired string being just as watertight as the original casing job.

TWO TYPES—FULL RANGE OF SIZES

Baash-Ross Packing Casing Bowls are available in two types—one with a *single* set of slips for gripping the top of the casing in the hole for use with short strings of casing . . . and the other with a *double* set of slips where extra gripping efficiency is desired on longer casing strings. In both types the packing element is essentially the same.

Both the Single and Double Slip Types are available in a complete range of casing sizes. In each size the O.D. of the Casing Bowl is not much greater than that of the casing joints, so that it can readily be run inside the surrounding casing of standard casing programs. Made of heat-treated alloy steel, each size of Casing Bowl has ample strength to withstand the most severe strains and pressures with a high safety factor.

Available through leading supply stores



Imperial tank battery No. 7, Leduc field.

came small oil discoveries by Standard Oil Company of California at Brooks, by Imperial at Armena, Pan-Western Oil at Baxter Lake. Gas discovery or extension wells were completed at Medicine Hat, Viking-Kinsella, Foremost, Hanna, St. Paul, Vermilion, and Keystone Valley. Other gas discoveries were mode at wildcats drilled for oil, but were abandoned for lack of an immediate market.

Turner Valley put out about 4.88 million barrels of oil in 1948 to boost its cumulative yield to about 98 million barrels. During the year Royalite Oil Company, Ltd., made an oil strike below former producing levels, and 1949 should bring its evaluation. Meanwhile, Home Oil Company, Ltd., is continuing extension drilling northward.

Current Trend

Two years ago there was fear that even Alberta's oil needs could not continue to be provided from domestic fields. A year ago Alberta was fully taken care of and there were reasonable grounds for hope that the prairie provinces could be covered by late 1949. During 1948 the picture further radically changed for the better. The entire prairie area is now assured of oil from Alberta in 1949, and during the coming year mounting volumes of oil will become available for export further east and west in Canada, and southward to the U. S.

The significance in the current trend was pointed up in a recent statement by H. H. Hewetson, president of Imperial Oils, Ltd., Canada's foremost producing company and a leader in the amazing developments of the past two years in Alberta. He declared that the two most significant factors in Canada's oil outlook are the likelihood of continued increases in product demand, and the beginning of what will eventually be a complete reversal of certain established lines of supply.

In 1947 oil demand in Canada was 7.5 barrels per capita, roughly half of the consumption level in the U. S. In 1948 Canada's per capita use of petroleum products advanced to 8.1 barrels, and a further rise is foreseen for 1949.

The U. S. in 1948 was for the first time a net importer of crude oil, but despite this fact, Canadian refineries have been, and still are, dependent for crude supplies on U. S. sources and other U. S. dollar sources. The significant point is that if sufficient crude reserves of the type required in Western Canada be found in Alberta or other provinces in the west, exports to the U. S. could alleviate dollar requirements for crude to be run in Canadian refineries elsewhere.

He estimates that Western Canada crude will back out U. S. crude as a source of supply by 1950, at which time it is thought that Prairie requirements will be met from domestic production. A proper program of marketing their oil in the U. S. would have the net effect of providing a much better trade balance with the U. S.

Already production is overtaking refining capacity. During 1949 it is thought that daily crude production will outdistance the crude equivalent of prairie demand for products, and with scheduled expansion of refining capacity in the prairies it would mean that they would be self-sufficient in terms of both producing and refining capacity. The traditional movement of products from Ontario and Montreal refineries to Manitoba should be eliminated shortly thereafter.

Can Meet Competition

Hewetson believes that Alberta production will be able to compete successfully with present U. S. Crude sources "wherever supplies from those sources impinge on the prairie market." Alberta crude, for example, he thinks will be able to compete at Winnipeg and so extend its market. He feels that every barrel which replaces U. S. crude will have the effect of savings varying from $3 to as much as $5 in U. S. funds.

Other studies being made include the practicability of moving reduced crude, from which some of the lighter products in large demand on the prairies have been removed, by rail from Edmonton to the Ioco refinery in British Colombia. There it might be processed to supply products in demand in British Colombia and thus back out some California products. A possible extension of the market in the same manner to Manitoba and Northwestern Ontario would compete with American Mid-Continent and with South American crude and products.

Hewetson reiterated Imperial's plans to build a 16-inch line from Nishku, near the Leduc field, to Regina in Saskatchewan at a cost of about $35 million, scheduled for completion next year, and able to carry as much as 100,000 barrels daily. The line would have the effect of moving the prolific Leduc and Redwater fields nearer the markets by eliminating costly rail hauls.

Devon, a town in Leduc field, was named for the Devonian lime.

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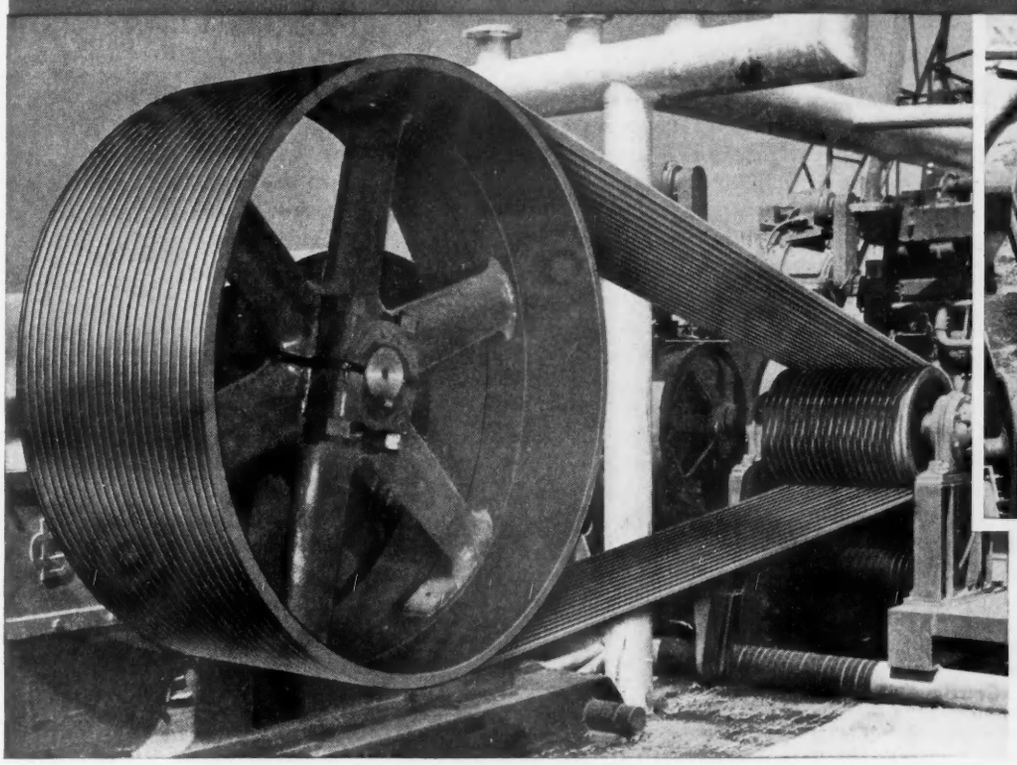

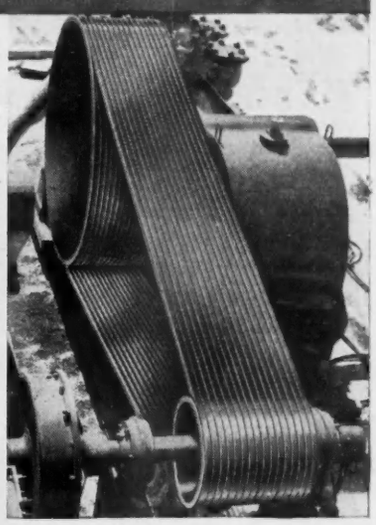

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THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

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Venezuela Output Up 13.8 Percent Over 1947 Period

PRODUCTION of crude in Venezuela through August had established a new peak 13.8 percent higher than the output for the first eight months of 1947. Production for the period totaled 322,447,000 barrels a day, or an average of 1,326,942 barrels a day over the entire eight months. Through the last four months of the year production has been maintained at a rate well above that established during the eight-month period.

Production is from 50 fields, but the greatest concentration is from a comparatively few areas. More than 89 percent of the total was derived from 13 fields, with the other 10.6 percent from the remaining 37 fields. The Bolivar Coastal fields (Cabimas, Tia Juana and Lagunillas) are still by far the greatest producers, accounting for 46.2 percent of the total, actual production figures amounting to 149,023,000 barrels over the eight months or a daily average of 579,844 barrels. Production from these three fields is more than the daily average production from Iran, the largest single producing country in the Middle East. Of the 13 principal fields, only two failed to show a gain over 1947 production. Jusepin and Santa Barbara fields, both in Eastern Venezuela, have apparently passed their peak and show declines of 17.4 percent and 20.5 percent, respectively. These fields, which received an enormous amount of drilling activity during the past several years, were quickly drilled up and brought to their production peaks, and current drilling is not sufficient to arrest declines in flush production. However, together these two fields have accounted for more than 17 million barrels of crude in the first eight months of 1948, or a daily average of 70,251 barrels.

Indicative of the shifting of sources of supply with advent of larger quantities of Middle East oil into the marketing picture, is the figures showing percentage of exports to Europe and to the U. S. During the first eight months of the year, exports of crude to European markets were 19.7 percent less than those for the comparable period in 1947, whereas exports to the U. S., Canada and other Western Hemisphere points were 22.6 percent, 23.1 percent and 12.3 percent higher than the preceding year.

Crude Oil Production

COUNTRY	COMPANY	PRODUCTION—In Barrels		
		Month	Barrels	Daily Average
†Bahrein	Bahrein Petroleum Co.	December	929,557	29,984
†Canada	All Operators	October	1,206,015	38,933
†Colombia	All Operators	November	2,398,181	79,939
Ecuador	Anglo-Ecuadorian Oilfields	November	134,155	4,472
	Ecuador Oilfields, Ltd.	November	48,834	1,494
†Egypt	Anglo-Egyptian Oilfields	November	877,239*	31,332
†France	All Operators	October	30,310	98
†Germany	All Operators	October	407,596	13,148
		November	388,500	12,950
†Iran	Anglo-Iranian Oil Company	November	16,726,089	557,536
†Iraq	Iraq Petroleum Company	October	1,471,339	47,463
†Kuwait	Kuwait Oil Company	November	5,936,975	197,899
†Mexico	All Operators	September	4,822,394	160,746
		October	4,977,630	160,569
Peru	International Pet. Co.	November	960,000	32,000
	Lobitos Oilfields, Ltd.	November	191,492	6,382
†Roumania	All Operators	September	2,485,350	82,845
†Saudi Arabia	Arabian American Oil Co.	November	14,453,870	481,796
Trinidad	Apex (Trinidad) Oilfields	November	242,036	8,068
	Kern Trinidad Oilfields	November	36,944	1,231
	Trinidad Central Oilfields	November	42,884	1,429
	Trinidad Leaseholds, Ltd.	November	513,505	17,117
	Trinidad Petroleum Dev.	November	214,649	7,155
	United British Oilfields, Trin.	November*	419,538	14,984
†Venezuela	All Operators	November	40,620,000	1,354,000

† Complete figures. * 4 Weeks Ending November 29.

Company Formed to Develop Resources Outside of U. S.

A company for the development of foreign oil resources has been formed by Continental Oil Company, The Ohio Oil Company and Amerada Petroleum Corporation, each of which holds a one-third interest. The firm is the Conorada Petroleum Corporation, formed to carry on oil exploration programs outside the U. S. and to engage in negotiations for foreign petroleum leases or concessions wherever prospects are favorable.

Arthur A. Curtice is president and director. Other directors are L. F. McCollum and James J. Cosgrove of Continental; J. C. Donnell II and W. B. Emory of Ohio Oil, and A. Jacobsen and E. H. McCollough of Amerada. Curtice is a consultant in geological work and petroleum engineering, and has been associated with the firms of Hoover, Curtice and Ruby, Inc., and Hoover, Curtice and Ruby, S. A. of Venezuela. The first of these firms has been changed in name to Exploration Contractors, Inc., while the Venezuelan company has been dissolved.

Arthur A. Curtice

Conorada is nominally capitalized, but Curtice says it will derive funds from its parent companies "in the amount and at the time needed."

"We are prepared to look any place in the world outside the U. S. for oil," Curtice said, but explained that Conorada has as yet no specific program. When asked if the new company might be interested in oil possibilities in Mexico, he replied that he had held lengthy discussions recently on that subject and is "thoroughly looking into the Mexican picture." However, he said, present terms offered by Mexico are not attractive.

He added that Conorada has no concrete plan involving the Middle East.

After Conorada has accessed foreign oil possibilities, the actual acquisition of favorable prospects and their subsequent development will be carried on either by the parent companies direct or by subsidiary companies to be organized for that purpose.

Curtice has served as technical adviser to many foreign governments in South America and in the Middle East and participated in drafting oil laws for various governments.

Formation of Conorada is in line with the recent trend whereby large domestic operators are turning to foreign sources

BJ SPEED-TRIP power slips saved the hole!

40 Stands of Drill Pipe Saved by SPEED-TRIP Power Slips

SPEED-TRIP BUILT-IN SAFETY FACTORS saved the hole on a California rig when the brakes went out. Pipe was going in the hole. 40 stands of drill pipe were running in when the driller hit the brakes and found he had no control. They were out like a boudoir light! Thinking fast, he tripped the Power-Slips. Acting under pressure, the slips immediately set on the drill pipe and stopped the string. Topside equipment . . . elevator, links, hook, and block . . . ended up on the floor, but no real damage was done to the rotary, Power Slips, or the hole.

THIS EXTRA SAFETY FACTOR is just one of the advantages of BJ *Speed-Trip* Power Slips. These Power Slips can be installed during drilling operations. They are the only Power Slips that can be swung 180 degrees away from the rotary thus giving maximum working room. BJ Power Slips have a double-acting pressure cylinder and a guide cylinder . . . You get pressure-raising and pressure-setting. Gravity lowering is slow and unbalanced. BJ Power Slips are the first pressure-lowered Slips. *Speed-Trip* Slips give you pressure-centering, uniform setting even when the pipe is not centered! FOR COMPLETE INFORMATION—write for the new BJ *Speed-Trip* Power Slips Bulletin.

BJ MEANS ENGINEERED OIL TOOLS

Byron Jackson Co.

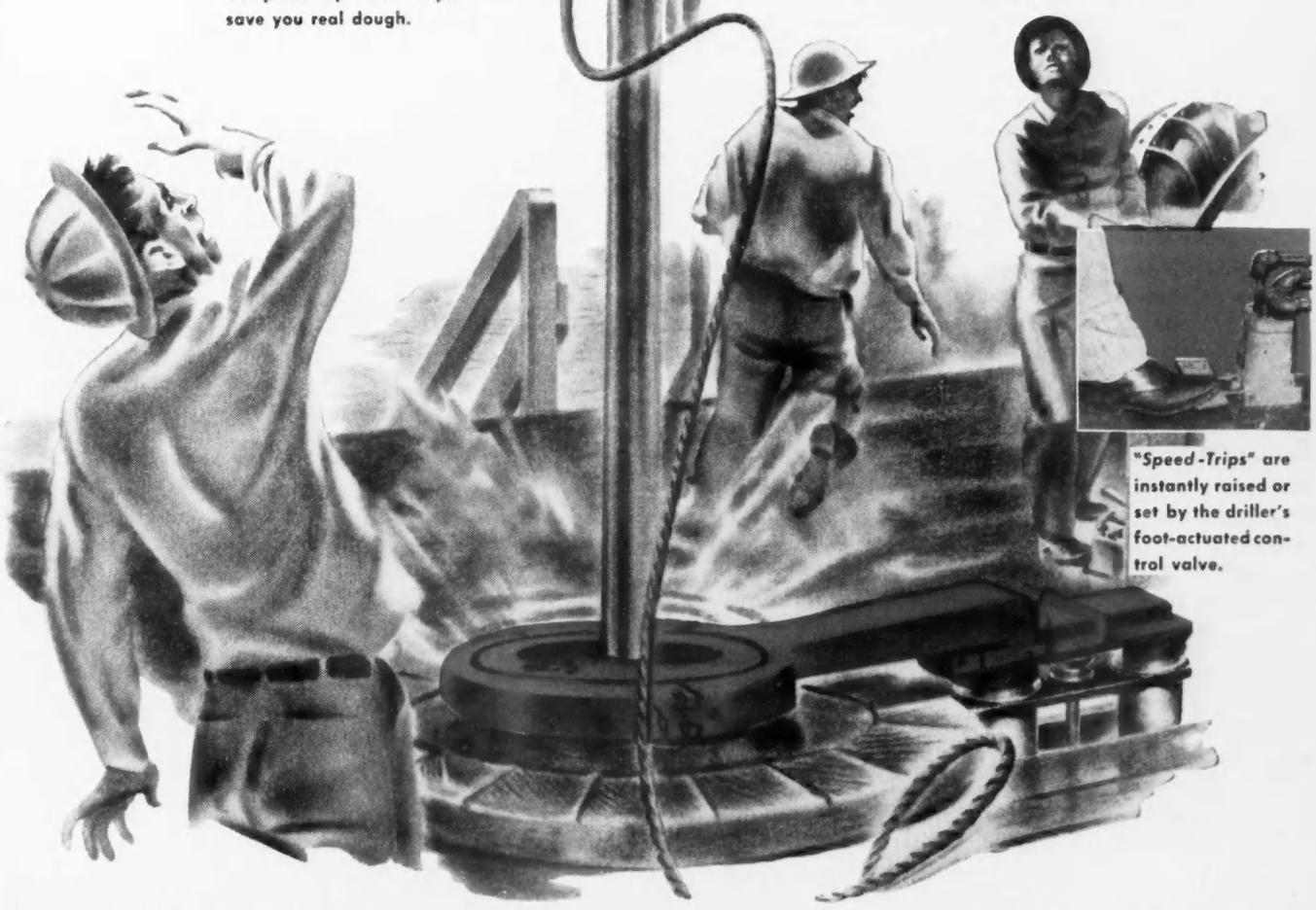
Since 1872

MAIN OFFICE AND PLANT

LOS ANGELES 54, CALIFORNIA

Mid-Continent Office and Plant, Houston 1, Texas
Export Office, New York 17, New York
Branches in All Principal Oil Fields

When all hell breaks loose, BJ *Speed-Trip* Power Slips save you real dough.



"*Speed-Trips*" are instantly raised or set by the driller's foot-actuated control valve.

for oil supplies. This trend presents what is perhaps the sharpest issue in the American petroleum industry today—imports. Many larger units are stepping up foreign importation of oil, especially from the Middle East, while other smaller operators are charging that such policy is proving destructive to the domestic producing sector of the industry. The Independent Petroleum Association of America contends that petroleum importation is beginning to dictate operation of the domestic industry.

The long-awaited National Oil Policy Committee's report, submitted to the National Petroleum Council in January, essentially sidestepped the issue of imports by one single reference to foreign oil—that the nation's import policy should encourage exploration and development efforts in the domestic industry.

With oil imports now at the 500,000-barrel-a-day level, many industry authorities see the threat of "dumping" on the domestic market. Conflicting views on the issue will be heard in numerous congressional hearings this year.

Clyde B. McDonald Is Named Houston Nomads' President

Clyde B. McDonald of A-1 Bit & Tool Company was elected president of the Houston Chapter of Nomads in January, succeeding Homer E. Thornhill.

Other officers selected by the chapter: Ed. M. Fontaine, National Tank Company, vice president; Edmond L. Lorehn, Cameron Iron Works, secretary-treasurer; Wayne Rives, *Oil & Gas Journal*, assistant secretary-treasurer; E. F. (Salty) Baldwin, Hughes Tool Company, sergeant-at-arms; Carrol W. Wood, Howard Smith Company, assistant sergeant-at-arms.

Regents for the coming year will be Charles M. Smythe, E. W. Saybolt & Company, and Homer E. Thornhill, Thornhill-Craver Company.

Lebanon Petroleum Gives Up On Deep Wildcat at Tripoli

Lebanon Petroleum Company has abandoned its deep wildcat test in the vicinity of Tripoli. Trebol 1 was on an anticlinal structure outlined by geophysics near the town of Tripoli during 1947, and the first test spudded late in that year, projected as a test of the Cretaceous and the Jurassic limestone formations.

Lebanon Petroleum is a subsidiary of Iraq Petroleum Company, holding a small concession under exploration permit surrounding the town of Tripoli, the only portion of the country thus far granted for petroleum exploration.

High Potential Indicated For New Well in Egypt

A new oil well has just been brought in on the Sinai Peninsula which alone has more than enough potential to balance Egypt's oil economy, making it a net exporter instead of an importer of oil. On the basis of short production tests made near the middle of January, the well flowed at a rate of 38,400 barrels daily, rivaling the famed Middle East wells in producing capacity.

Drilled by Anglo-Egyptian Oilfields, Ltd. (Shell Group) and Socony-Vacuum Oil Company on jointly-held acreage, the big producer is the fifth well to be drilled in the Sudr field which was discovered during 1947, and the oil is apparently coming from a lower horizon. The operators have not yet released full figures regarding the thickness of the producing sand, or possible extent of the area which might be involved. Total depth of the Sudr 5 is 3427 feet, some 800 feet deeper than the original Miocene discovery pay, and the producing zone has been identified as Eocene sand.

The companies have stated that technical considerations and lack of sufficient knowledge of reservoir conditions will not permit production approximating the rate indicated as the potential of the well. In addition, there does not exist sufficient storage or pipe line capacity to transport this amount of production. A six-inch line is being built to the port on the Gulf of Suez, and there is already under consideration the possibility of a large-sized line northward from Sudr to an outlet near Port Said on the Mediterranean. Such a line, which would cost an estimated $5 million, would serve the immediate objective of by-passing the Suez Canal and would roughly parallel the canal, needing a distance of only a little more than 100 miles to reach the Mediterranean.

Any estimates as to the possible overall value of the new discovery will probably wait for completion of the next Eocene test. The rig has already been moved to location for Sudr 6, just 2700 feet northwest of the No. 5. The new development has taken place on the northwest side of the field as originally found.

According to the latest terms of concession grants in Egypt, the government is entitled to a 15 percent royalty, plus an option to purchase on an agreed basis up to 20 percent of the remainder of the oil.

Discovery of a field of this magnitude would be particularly important to the European supply picture, since it is so much more readily available to Mediterranean points at a time when the building and projected outlets for Persian Gulf oil are still pending. It should also do much to stimulate interest in Egypt as an almost untouched area for exploration.

Colombia Maintains Production Despite Domestic Problems

The close of 1948 saw Colombia producing at a rate which, if maintained throughout 1949, will see new records set, although production was prevented by labor and other internal troubles from equaling the 1947 high level. The year's production was 23,791,510 barrels, representing a loss of slightly more than one month's production during the year.

A new record for a single month was set in October when production was 2,492,125 barrels. The daily average of 80,391 barrels in October was also a new record, the third is an many months.

In November, the total was only slightly off, with 2,398,181 barrels, or a daily average of 79,717 barrels produced.

The labor pact, signing of which had threatened to precipitate a general strike throughout the country, was finally settled early in December. As was expected, the pact provided for additional benefits for labor, additional power for labor-management committees, and increases in pay ranging from 10 to 20 percent.

Airborne Magnetometer Survey Started in Canadian Province

The Province of Ontario, Canada, has contracted with one of the leading American air-survey firms for an extensive airborne magnetometer survey, and first flights in the program are now being started.

The area covered will include about 1200 square miles near Trenton, and the magnetic data will be delivered to the Department of Mines and Resources of the Dominion of Canada. The current program will serve as an extension of aerial magnetic studies already performed in Ontario by the Canadian Geological Survey.

It is expected that the complete survey will require about six weeks, in spite of the problems of winter flying weather and temperatures of 10 to 20 degrees below zero common in the survey area at this time of the year. It will be started on the second anniversary of the world's first commercial airborne magnetometer survey performed in 1947 for large Canadian mining interests.

STOKVIS LOOK AND LISTEN

Tubing Tool Joints

WORKOVER
DEEPENING
COMPLETION

Gulf Tubing Tool Joint Quiz

Will Gulf joints leak under high squeeze pressure?

No. Users report no trace of leak at 5200#.

Will worn joints leak?

No. Users with 100 Gulf joints in string report no leakage after 70 round trips.

Will Gulf joints break out easily?

Yes. Approximately 50% of torque used to make up is required to break out.

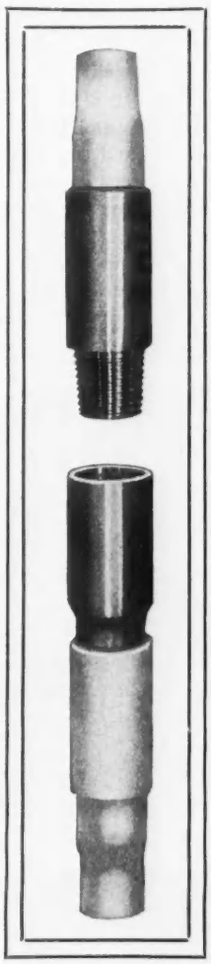
Can power tongs be used with Gulf joints?

Yes. Joint has greater tong room length than conventional thread and collar tubing.

Note: Three and a fraction revolutions required for shoulder fit.

Can Gulf joints be reworked?

Yes. Ample length for tubing thread or tool joint thread.



Doesn't it take too long to install and remove Gulf joints after use?

On one round trip job—yes. Such jobs are rare. On two or more round trips, time is saved even though ¼ of round trip time required to remove joints after last trip. Major companies make it standard practice to install joints regardless of number of trips.

Will Gulf Tool Joints save round trip time?

Yes.

25 - 40% approximately. Tubing can be run at speed equal to that of drill pipe.

Is O.D. same as tubing coupling?

Yes.

Is inside bore same as tubing?

Yes.

How much time required to install joints?

None. Joints installed during elevator upward travel for next stand.

Gulf Tubing Tool Joint Specifications

Nominal Size	*TYPE CONNECTION		DIAMETERS		LENGTHS			Net Weight Assm'ld. Pounds	Taper Per Foot	Threads Per Inch	Length Thread Section
	Pin Down Box Up	Double Box	O.D.	I.D.	Pin	Box	Assm'ld.				
2"	PB	DB	3.06"	1.99"	8"	8"	13½"	14	1½"	4	2½"
2½"	PB	DB	3.66"	2.44"	8½"	8½"	14½"	20	1½"	4	2½"

*8 or 10 thread connections optional. * External upset or plain end type optional.

Gulf Tool Company, Houston, Texas

Export Representatives

R. S. STOKVIS & SONS, INC.

17 BATTERY PLACE

NEW YORK 4, N. Y.

ESTABLISHED 1844

Pakistan Field Development Indicates Increased Output

Developments in Pakistan have proceeded to the point where substantially increased output may be attained in 1949, it is indicated by recent reports by Attock Oil Company. During the early part of last year, operations were hampered somewhat by the communal troubles, but more recently it has been possible to continue with plans for further development in the new Balkassar and Joya Mair fields of the Punjab area. The third well drilled at Balkassar furnished a second producer from the Sakesar limestone, which has responded to chemical treatment. It now appears that the field will be capable of sustained production which would justify the construction of the 34-mile pipe line which late in the year was completed to a junction with the main line from Dhulian to Rawalpindi. Drilling will continue in an effort to increase the potential. Until the line was completed, both Balkassar and Joya Mair production was limited to the uncertain service provided by a railway line.

In West Pakistan, Burmah Oil Company's deep test near the city of Hyderabad was drilling below 3300 feet. The progress of this test is being followed closely, since it is scheduled for an ultimate depth of 10,000 feet. Lakhra 1 is a test planned since 1938, when Burmah Oil Company carried out an intensive geological survey. Before the survey the area had been studied at intervals over a period of more than 30 years. A location had been selected for the deep wildcat at the time the operation was halted by World War II. Since the war, unsettled conditions prevented actual operation until early last year.

Situated on a broad anticlinal fold in desert territory about 35 miles northwest of Hyderabad, it was necessary to build a 12-mile road through the desert from the railway, where a special siding was built to receive materials. A camp was constructed with complete living facilities, and heavy drilling equipment was moved in. The rig is a heavy-duty outfit capable of going below 15,000 feet, powered by automotive-type diesel engines.

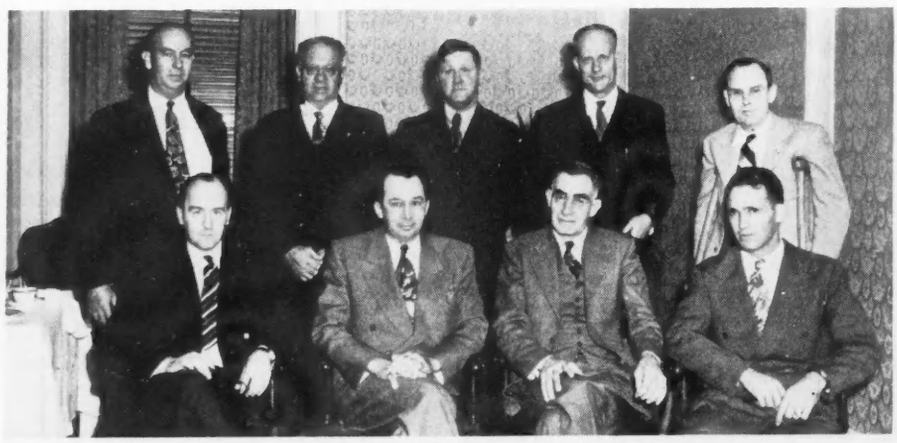
Spudded late in May, progress has been slow, even in the surface formations. A string of 16-inch surface casing was cemented to 1920 feet, and plans are to carry a 14¾-inch hole to 8000 feet, where it will probably set intermediate pipe. Since drilling below the surface pipe most of the hole has been made through dense and extremely hard limestone and basalt in formations of Paleocene age, and progress has averaged only about seven feet per hour.

20,000 Tons of Pipe to Be Bought for Argentine Line

The Argentine Direccion General del Gas del Estado has been authorized to purchase an additional 20,000 tons of seamless steel pipe for use on its gas trunk line project, according to the U. S. Department of Commerce.

Due principally to delays in receiving various materials, the line is believed to be somewhat behind the original construction schedule, but is expected to be completed this year. When finished it will deliver gas 1200 miles from portions of the Comodoro Rivadavia district to Buenos Aires to help bolster Argentina's fuel economy. It is also scheduled to supply communities near the route through branch lines. Original plans called for building around the Pillahuinco and La Ventana mountains in the southern part of Buenos Aires province, but the continued shortage of steel for line pipe has dictated that the line build along a shorter route across the mountains.

The Direccion General del Gas del Estado is the agency which holds a virtual monopoly on gas distribution for Argentina, and its activities will include, in addition to building lines from gas wells in the southern part of the country, the setting up of facilities for the manufacture of bottled gas. It has recently received an appropriation of 100 million pesos (approximately $25 million) from the Five Year Plan funds, of which Ps12 million is to be used for the bottled gas facilities, 44 million for pipe line construction, and 44 million for construction of distributing stations and machinery.



NOMADS VISITORS—Top: Foreign guests who attended a recent meeting of the Los Angeles Chapter of Nomads. Seated, left to right: G. K. Mounteney, Trinidad Petroleum Development Company; M. D. Freeland, Bahrein Petroleum Company, Ltd.; C. H. Hendershott, Bahrein Petroleum Company, Ltd.; and M. H. Jackson, Brown Drilling Company. Standing, left to right: T. A. Connor, Iraq Petroleum Company; E. G. Dobson, Texas Petroleum Company; Charles M. White, Iraq Petroleum Company; H. D. Nunez, Socony Vacuum Oil Company; and C. H. Strickland, Iraq Petroleum Company.

Guests at the January meeting of the Houston Chapter of Nomads are shown below. Left to right: Paul Lehr, Shell Oil Company, Los Angeles; R. B. Starke, Caribbean Petroleum Company, Maracaibo, Venezuela; O. Kirkpatrick, Caribbean Petroleum Company, Maracaibo; G. K. Mounteney, Trinidad Petroleum Development Company, Bombay, India.

NEW AND IMPROVED Equipment SUPPLEMENTING COMPOSITE CATALOG

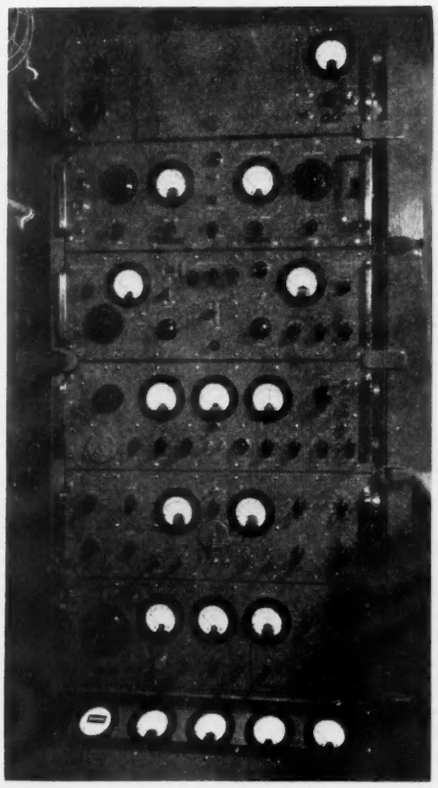
New and improved equipment of manufacturers who describe their products or services in the current Composite Catalog

26—Well Logging Unit

This item supplements Schlumberger Well Surveying Corporation's data as shown on pages 3731-3736 of Composite Catalog.

The Schlumberger well logging unit, in contrast with previous units, is equipped to record simultaneously four SP curves on one trip out of the hole. This record is available to the company representative on location.

These new units contain permanent



panels for all services. From top to bottom, they are (1) open hole section logging, (2) Gamma ray logging, (3) photoclinometer and dipmeter surveys, (4) gun perforating, side wall coring and casing collar locator, (5) electric logging, and (6) induction logging.

For additional information write Schlumberger Well Surveying Corporation, Houston, *referring to* WORLD OIL *item 26.*

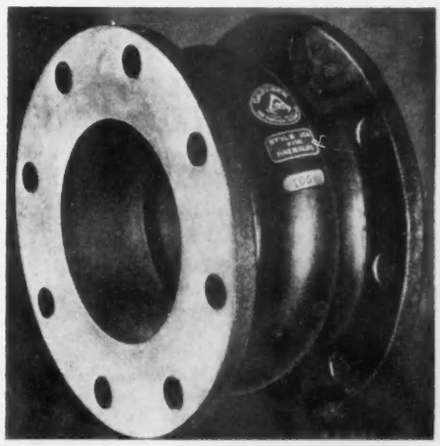
27—Rubber Expansion Joint

This item supplements The Garlock Packing Company data as shown on page 1384 of Composite Catalog.

New rubber expansion joints are flexible connections designed for installation in pipe lines to relieve stresses in piping and equipment. The standard expansion joints are suitable for handling hot or cold water, brine or exhaust steam at temperatures not in excess of 180 degrees. Joints with synthetic rubber lining are available for service involving oils, acids or mild caustic solutions.

Flexibility is provided by a central arch in the body of the spool-type joint located midway between the two flanges. This arch flexes with expansion and contraction of the piping, thus absorbing stresses in the line. The rubber flanges of the expansion joint are made integral with the body of the joint.

The joints are made for pressure, for vacuum, or for pressure and vacuum.



Pressure-type joints are suitable for operating pressures from 40 to 125 pounds per square inch, and vacuum-type joints are suitable for a vacuum of 30 inches of mercury.

For additional information write The Garlock Packing Company, Palmyra, N. Y., *referring to* WORLD OIL *item 27.*

28—Pipe Wiper

This item supplements the Hinderliter Tool Company Division data as shown on pages 1723-1734 of the Composite Catalog.

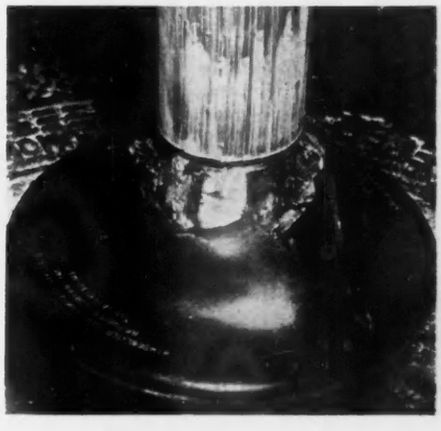
A flexible rubber pipe wiper is designed to permit passage of bits as well as tool joints and protectors, called the Hinderliter "Full Flex" Pipe Wiper, it consists of two layers of abrasive-resistant rubber joined at the circumference around a steel reinforcing ring. The center of each layer is cut out to suit outside diameter of pipe, and each layer is split at right angles to the other.

Although in normal position the wiper fits snugly around the pipe, it has sufficient flexibility to pass tool joints, drill collars and protectors of greater diameter than the pipe, including the bit.

Made of high quality materials, the "Full Flex" is tough and resistant to wear or damage. The steel ring, being completely enclosed in rubber, is spark proof.

The wiper is made for pipe sizes from 2⅜ to 6⅝ inches, inclusive, and in outside diameters of 15, 17 and 19 inches. The 15-inch diameter will pass bits up to 6¾ inches; the 17-inch will pass bits to 9 inches; and the 19-inch will pass bits to 11 inches.

For additional information, write Hinderliter Tool Company, Division of H. K. Porter Company, Inc., P. O. Box 2650, Tulsa, *referring to* WORLD OIL *item 28.*



PENBERTHY

REFLEX and TRANSPARENT

DROP FORGED STEEL LIQUID LEVEL GAGES

PENBERTHY
REFLEX
Drop Forged Steel
Liquid Level Gage
Empty Space Shows White
Liquid Shows Black

Due to "Reflex" principle, liquid always shows black and empty space white. Liquid level is indicated instantly and unmistakably. Made of temperature resisting alloy steel for high pressure and temperature service. Conforms with API and ASME requirements.

PENBERTHY
TRANSPARENT
Drop Forged Steel
Liquid Level
GAGES

Glass front and rear permits observation of color and density of liquids under high pressures and/or temperatures. Highest quality—made of temperature resisting alloy steel. Conforms with API and ASME requirements.

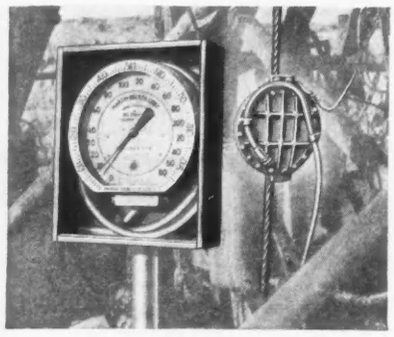
3277-C

PENBERTHY PRODUCTS INCORPORATED

PENBERTHY INJECTOR CO.
Detroit 2, Mich.
Canadian Plant—Windsor, Ontario

NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG



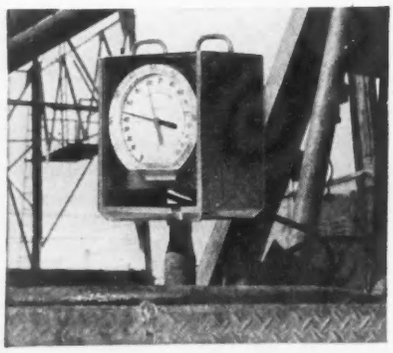
The Clipper Sealtite permanently installed on a trailer mounted rig. Lowering the mast and moving in no way interferes with this installation.

29—Weight Indicators

This item supplements Martin-Decker Corporation's data as shown on pages 2505-2536 of Composite Catalog.

The Martin-Decker production model clipper Sealtite Weight Indicator is designed for small rigs, production hoists, etc. It is 14 x 17 x 12 inches. Dependable adjusters permit just the right degree of sensitivity and readability. The Vernier Weight Indicator with 6 to 1 ratio is included and is ideal for fishing jobs, etc. Vacuum loaded at the factory and permanently sealed, they are load tested on certified test machines.

When attached to the mast as a permanent instrument, these weight indicators remain in place when the mast is lowered or the rig is moved. The gauge, hose and diaphragm are permanently sealed and ready for installation on the rig. Only one installation is required. The gauge is mounted in the most convenient position on a permanent bracket or post. The diaphragm is attached to the dead line and remains there.



The Portable Model Clipper Sealtite. Ideal for any small space. Note convenience of handles. Can be installed permanently if desired.

For additional information, write Martin-Decker Corporation, Cherry Avenue and Wardlow, Long Beach 7, Calif., *referring to* WORLD OIL *item* 29.

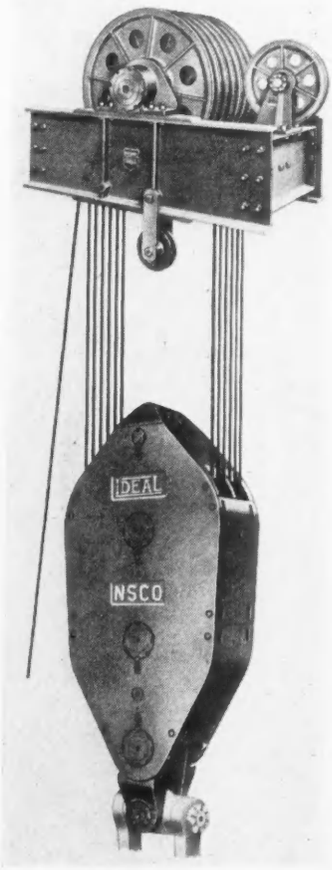
30—Heavy Duty Blocks

This item supplements The National Supply Company's data as shown on pages 2793-2892 of Composite Catalog.

Designed for handling maximum casing loads, with reserve capacity in excess of loads allowable on 1½-inch wire line, the Ideal crown block and traveling block have ample capacity for 540-ton loads.

Ideal 630-ton crown block, type 760-T, consists of seven sheaves 60 inches in diameter on a 12½-inch diameter shaft nearly five feet long, which is supported by 8 by 35 inch main beam members nine feet long.

The Ideal 540-ton traveling block, type 660-TD, consists of six sheaves 60 inches in diameter on two 10¼-inch shafts, four sheaves above and two below, inclosed in a block 13¼ feet long, less than three feet thick, and five feet, eight inches wide.

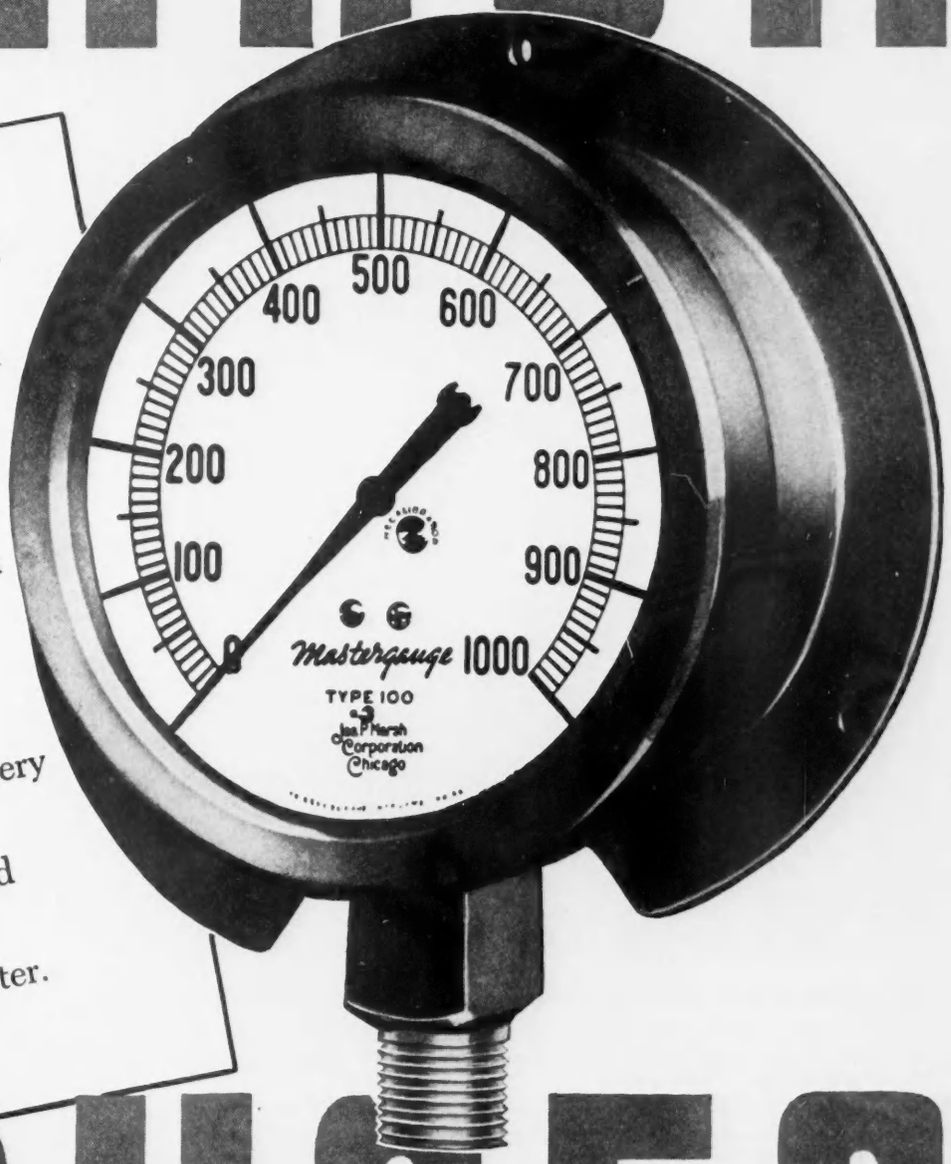


The use of 60-inch diameter sheaves assures long life for the wire line, and the large double row tapered bearings offer the ultimate in bearing life expectancy.

For additional information, write The National Supply Company, Box 899, Toledo 1, Ohio, *referring to* WORLD OIL *item* 30.

MARSH

All that we have learned in 80 years of precision instrument making stands before you in the design and construction of every Marsh Gauge and Dial Thermometer.



GAUGES

JAS. P. MARSH CORPORATION • DEPT. K, SKOKIE, ILLINOIS

The Jas. P. Marsh line includes gauges especially designed for blenders, boilers, burners, capping, Christmas trees, columns, heaters, hydrogen units, instrument panels, pumps, Reid vapor bombs, scrubbers, separators, mud pumps, stills, towers, and other applications including oxygen and welding gauges.

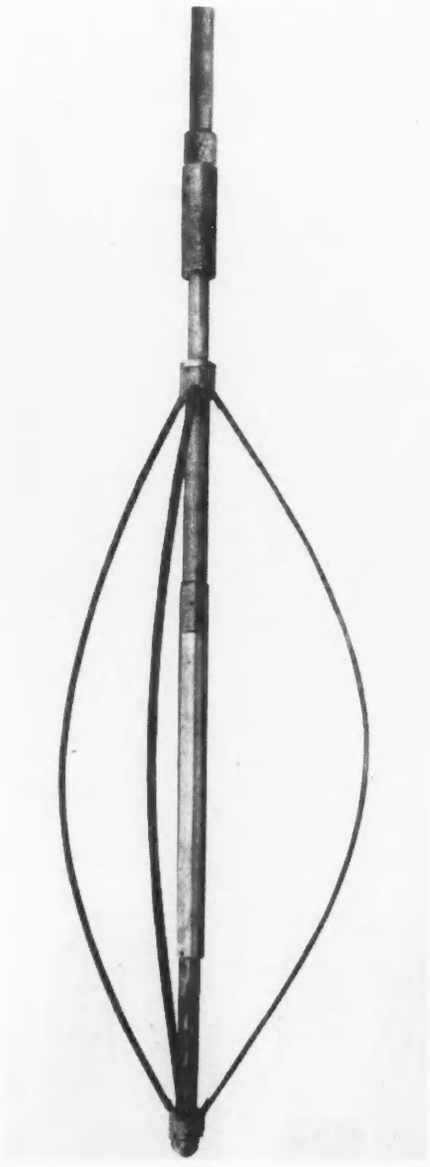
31—Open Hole Section Gauge

This item supplements the Schlumberger Well Surveying Corporation's data as shown on pages 3731-3736 of Composite Catalog.

The open hole section gauge was specially designed to meet a need for an accurate hole gauge of substantial construction which could be run either up or down a drill hole without hanging up.

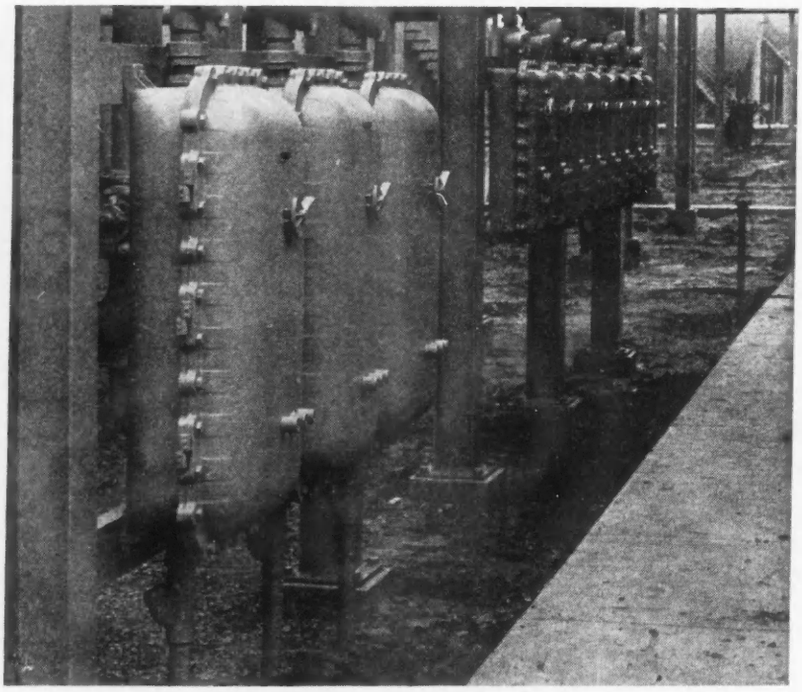
In most cases volume is of first consideration in open hole studies. For this reason, the gauge is designed to produce at the surface an electrical recording of hole size in terms of cross-sectional area. The volume of the hole can be quickly and accurately determined by measuring the area enclosed by the curve with a planimeter. The hole diameter at any given point may be obtained by reading the log curve with respect to a graduated diameter scale located at the bottom of the chart heading.

The instrument is run into the hole on the same cable used for electrical logging, and the log of the hole is available at the well upon conclusion of the survey. The time required for surveying a given interval of hole may be based on a running speed of approximately 6000 feet per hour. The springs on the instrument when expanded to their greatest arc will correspond to a hole diameter of 36 inches.



For additional information write Schlumberger Well Surveying Corporation, 2720 Leeland, Houston, Texas, *referring to* WORLD OIL *item* 31.

Thousands in use!



Nelson Class 420 Explosion Proof Combination Motor Starters

Because they provide automatic protection and control at all times, literally thousands of our Class 420 Explosion Proof Combination Motor Starters are in use throughout the Oil Industry.

The Magnetic Motor Starter gives "across-the-line" starting. The Air Circuit Breaker is used as a disconnect switch and provides short circuit protection by means of instantaneous magnetic trips. Where desired, Control Stations can be mounted on the covers of the starters.

Photograph shows Nelson Class 420 Combination Starters installed at Gas Re-cycling Plant. Three Size 4 Starters are in foreground; and eight Size 2 Starters in background. Write for descriptive Bulletin 420.

NELSON Electric MANUFACTURING CO.

217 North Detroit TULSA, OKLAHOMA Telephone 2-5131

Manufacturers of: Explosion-Proof Motor Controls, Junction Boxes and Enclosures, Circuit Breakers and Lighting Panels. Oil Field Motor Controls, Automatic Pipe Line Sampling Devices, Cathodic Protection Equipment, Switchboards, Instrument and control Panels, Unit Substations.

it's right at home in TOUGH WELLS

This depression in the pin end provides quick identification of the Bethlehem "46," regardless of length of service or well wear.

For a rod that's right at home in tough pumping jobs, even in corrosive wells, choose the Bethlehem "46" Sucker Rod. The Bethlehem "46" is ideal for heavy-pumping duty because it's made of corrosion-resistant nickel-molybdenum steel and comes fully normalized and fully tempered along its entire length. The rod meets A.P.I. specifications, too, and is furnished with carburized, hardened-and-ground A4615 steel couplings.

How about giving the Bethlehem "46" a try? But don't pick a soft spot for it. Put it to work where it belongs—in your tough wells.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

BETHLEHEM *Sucker Rods*

BETHLEHEM STEEL

BIT CUTTING ANALYSIS

(New Technique)

PERMEABILITY

Porosity and Saturation Data from Reverse Circulation Bit Cuttings

•

Oil in Place, **Connate Water** by Restored State Method

•

Analysis of Oil Field Brines

•

Core Analysis

•

Secondary Recovery

•

Petroleum Production Engineers

WHALEY ENGINEERING COMPANY

PETROLEUM LABORATORIES

118 W. Cameron, Tulsa, Okla. **Ph. 2-1955**

DIAMOND CORING

brings...

✓ **SPEEDIER PENETRATION**

and...

✓ **GREATER RECOVERIES**

✓ **DIAMOND CORE BITS ...for sale**

✓ **SPECIAL CORE BARRELS for rent or sale**

✓ **SERVICE ENGINEERS**

DIAMOND OIL WELL DRILLING COMPANY

MIDLAND, TEXAS

815 MIDLAND TOWER PHONE 2710

OKLAHOMA CITY, OKLA.

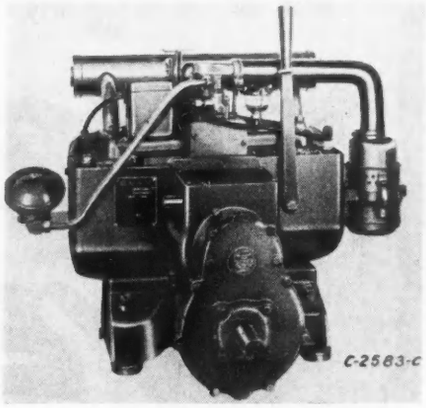
208 SW 44TH ST. PHONE 62-1538

NEW EQUIPMENT

SUPPLEMENTING COMPOSITE CATALOG

32—Pumping Engine

This item supplements D. W. Onan & Sons, Inc., data as shown on pages 3256-3257 of Composite Catalog.



For continuous heavy-duty service on tough oil field pumping jobs, a two-cylinder air-cooled pumping engine has been developed. The engine, model CK-4T Specification 49, develops 1000 inch pound torque with a 960-foot piston speed, and is rated at 5½-horsepower continuous duty.

Gas-gasoline carburetion with secondary regulator permits operating on both gasoline or natural gas. A four-quart oil sump has a drain and fill plug on both sides. The engine has a high tension magneto ignition, and is air-cooled by an axial-flow blower.

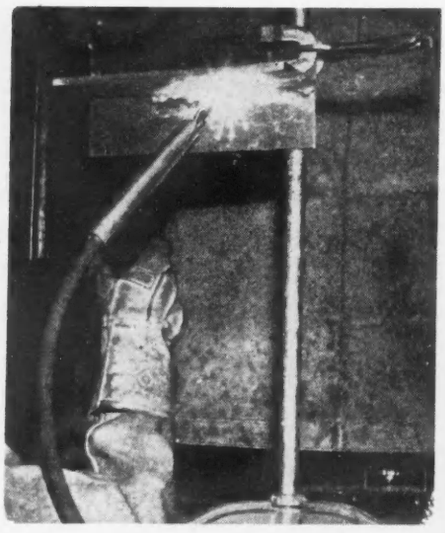
For additional information write D. W. Onan & Sons, Inc., 3621 Royalston Avenue, Minneapolis, *referring to* WORLD OIL *item 32.*

33—Welding Process

This item supplements the Air Reduction Sales Company data as shown on pages 146-147 of the Composite catalog.

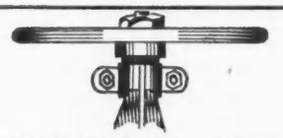
A new welding method, known as the "Aircomatic" process, may be used for welding heavy sections of aluminum and aluminum alloys at wire feet speeds ranging from 100 to 300 inches per minute.

The process is a form of gas-shielded, metal arc welding, but the conventional non-consumable electrode has been replaced by a continuously fed, consumable

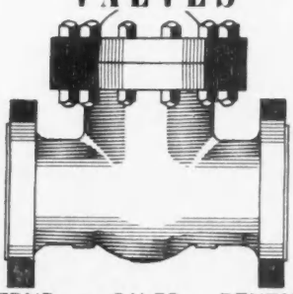


wire. This wire is fed to the work through the barrel of a welding "gun." The filler metal carries welding current and an arc is maintained between the end of the wire and the work. Power is supplied from a standard direct current welding generator and argon is used as the shielding gas.

For additional information write Air Reduction Sales Company, 60 East 42nd Street, New York, *referring to* WORLD OIL *item 33.*



RECONDITIONED VALVES



REPAIR – SALES – RENTAL

ALL TYPES OF OIL FIELD VALVES

Odessa Valve & Machine Co.

P. O. BOX 1068 PHONE 3632

PENWELL & T. P. TRACKS, ODESSA, TEXAS

BARRET

SPECIALIZING IN MAGNETIC SURVEYS

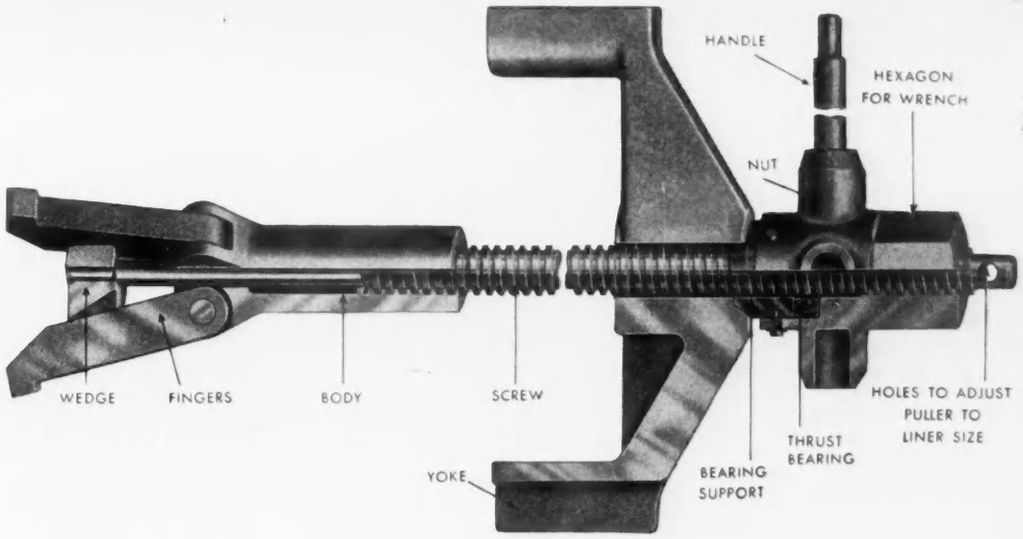
Contracts accepted for domestic and foreign projects, using the most improved instrumental and interpretative technique.

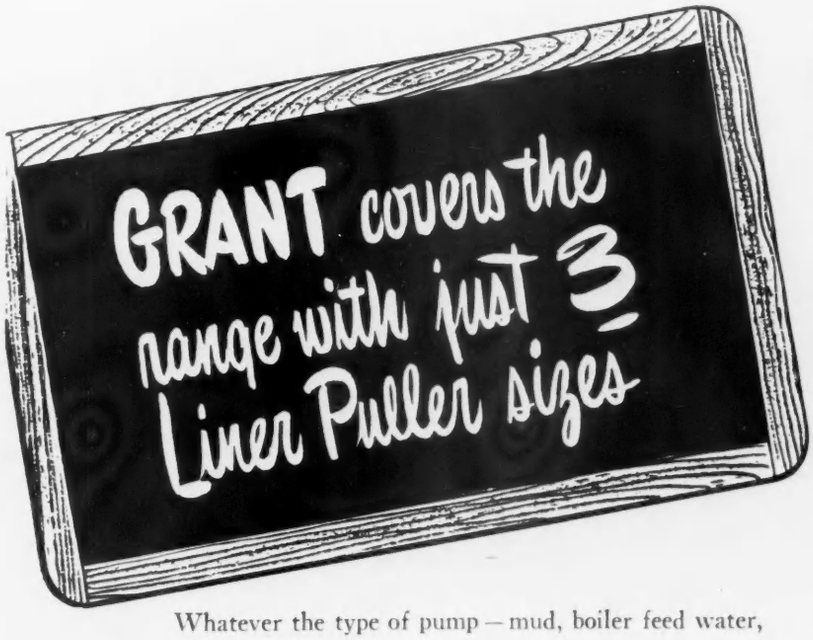
William M. Barret, Inc.

Consulting Geophysicists

GIDDENS-LANE BUILDING

SHREVEPORT, LOUISIANA





Whatever the type of pump — mud, boiler feed water, or any other — if it has a removable liner you can pull it quickly and easily with the Grant Liner Puller. This versatile tool has no loose parts to get lost or require changing for different liner sizes. One tool pulls all liners within its size range and just 3 tools pull *all* commonly used liner sizes.

The Grant Liner Puller is designed to prevent damage to the liner bore . . . to pull direct and straight from the end of the liner . . . and to pull the most stubborn liner without fail. Its action is fast, positive and powerful.

SIMPLE TO OPERATE

Turning the screw clockwise collapses the fingers until they can be inserted through the liner and pass beyond the inner end of the liner. The yoke is next passed over the end of the pump cylinder on the studs, straddling the screw.

Simply rotating the nut clockwise exerts tremendous pull and results in quick removal of even the most stubborn liner. The nut is equipped with a roller thrust bearing to reduce friction and make turning easier, and a hexagon extension permits use of a wrench if necessary to gain additional power. The entire puller can be easily removed from the liner whenever desired.

The Grant Liner Puller is a mighty handy tool to have on the rig when a pump is down for liner renewal. It's of heavy steel construction throughout to give you years of service, and just three sizes meet all liner pulling needs. *The Grant representative in your territory will gladly supply you with complete details — or write direct!*

Proven GRANT Tools
Used Where Performance Counts

Hydrostatic Bailers	Bulletin No. 11
Liner Pullers	Bulletin No. 14
Pressure Releases	Bulletin No. 15
Casing Scrapers	Bulletin No. 17
Wall Scrapers	Bulletin No. 20
Bottom Hole Scrapers	Bulletin No. 21
Underreamers (Rotary)	Bulletin No. 24
Underreamers (Cable Tool)	Bulletin No. 27
Hole Enlargers	Bulletin No. 38
Reamers	Bulletin No. 43
Hydrostatic Perforation Cleaners	Bulletin No. 50
Dump Bailers	Bulletin No. 51
Roller Cutter Shale Bits	Bulletin No. 54
Sand Pumps	Bulletin No. 55
Impression Block Tool	Bulletin No. 56
Well Cleanout Equipment	Bulletin No. 57

Write for Descriptive Bulletins on these GRANT Tools

GRANT OIL TOOL COMPANY

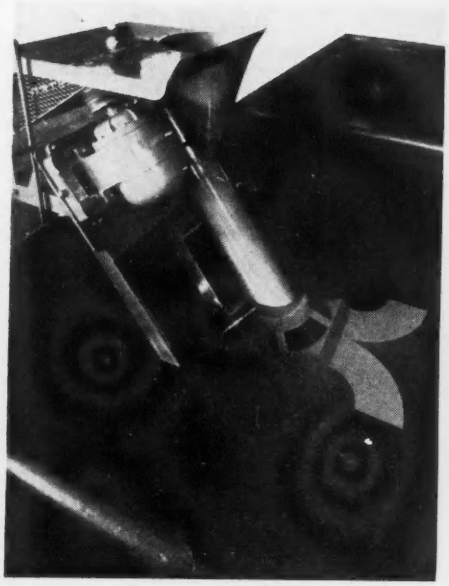
Main Office and Plant: 2042 East Vernon, Los Angeles 11, California

Branches at Bakersfield, Avenal and Ventura, California, and at Odessa and Houston, Texas

34—Mud Mixing Unit

This item supplements Texas Iron Works, Inc., data as shown on pages 4025-4060 of Composite Catalog.

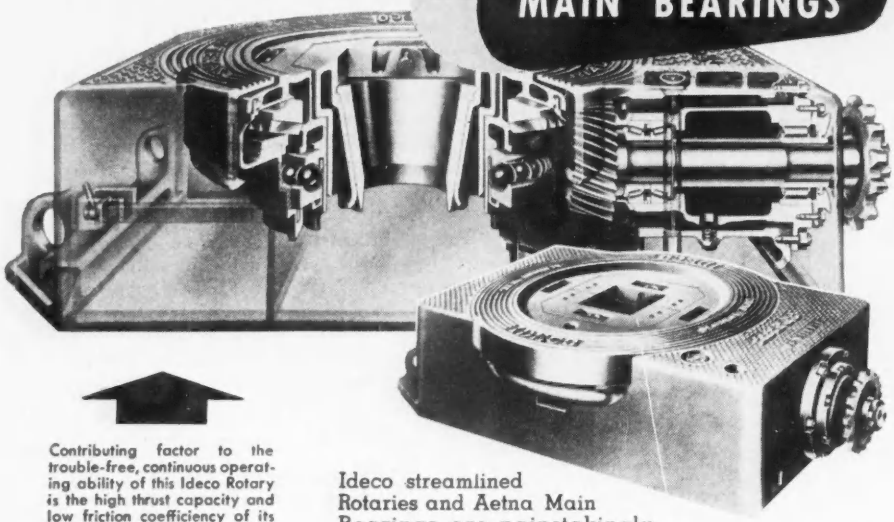
With the Mudmaster, sack material is fed into the hopper at the top of the unit and is conveyed through the mixing tube by a screw conveyor. A propeller on the lower end of the conveyor shaft, inside of the duct, stirs the fluid mixture while vanes on the shaft break up the weighting materials, clay and chemicals being fed. If the mixer is to be located on the end of a long narrow tank or pit the diverging ducts may be replaced by a straight duct. The unit may either be mounted on the side of a steel tank as a permanent fixture or it may be used in earthen pots and put into position by use of skids. A ten-horsepower steam turbine, electric motor or internal combustion engine furnishes power for the mixer.



For additional information write Texas Iron Works, Inc., 1401-23 Maury Street, Houston, *referring to* WORLD OIL *item* 34.

Winning Combination

IDECO ROTARIES + Aetna MAIN BEARINGS



Contributing factor to the trouble-free, continuous operating ability of this Ideco Rotary is the high thrust capacity and low friction coefficiency of its angular contact main bearing . . . by AETNA.

Ideco streamlined Rotaries and Aetna Main Bearings are painstakingly engineered to work together—precision built to meet today's demand for "making hole" deeper, faster, more economically.

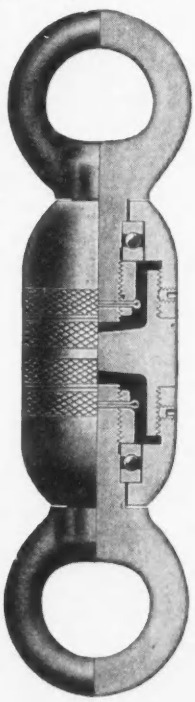
This is a typical example of how Aetna's specialized experience, rigidly controlled hardening and grinding methods combine to pack more and better bearing performance into a given amount of steel. Your equipment can benefit, too, from the plus value built into every Aetna bearing. Let's talk it over?

AETNA BALL AND ROLLER BEARING COMPANY
4600 Schubert Ave., Chicago 39, Illinois

Aetna
BALL AND ROLLER BEARINGS

35—Swivel

This item supplements the L-K Pump Valve Company data as shown on pages 2180-2183 of Composite Catalog.



A new swivel is designed particularly for heavy duty hoisting around drilling rigs but is serviceable also in marine work and general industry.

The unit is of properly heat treated alloy steel with forged steel rings at each end that will take manila rope up to 2⅝ inches in diameter. Grease-packed ball bearings in each end prevent kinking and twisting of lines. Tests show this swivel to have a breaking strength of in excess of 30 tons. The swivel weighs 8½ pounds, is 11½ inches long. It can be furnished galvanized for marine use and in smaller sizes if desired.

For additional information write L-K Pump Valve Company, 632 North Edgewood, Houston, Texas, *referring to* WORLD OIL *item* 35.

consider this OUTSTANDING ADVANTAGE of the famous WHELAND SWIVEL

WASH PIPE, special nickel alloy steel, carburized, precision machined, wearing surface heat treated to 600 Brinnell hardness, precision ground, polished and honed for maximum smoothness and minimum packing wear. Wash pipe outside diameters are precision machined in one operation assuring perfect concentricity and perfect alignment. No place to form pockets or restrict mud flow.

Wash pipes can be replaced with minimum time and effort. With just average care, the replacement goes in EASILY and in PERFECT ALIGNMENT.

ALSO IMPORTANT: Spring loaded, lubricated, extra deep, chevron type, wash pipe packing. Lower stem lubricated packing is triple sealed. All packings automatically adjusted, pressure grease lubricated through readily accessible fittings.

All bearings have capacity far in excess of Wheland's capacity ratings. Timken main load bearing with radial and thrust above and below to maintain perfect stem alignment. Upper thrust bearing, tapered cone. All bearings positively sealed off from mud and run in circulated, cooled oil. Large oil capacity.

Long radius gooseneck, streamlined manganese vanadium steel body, lower grease seal, special hold down construction, freedom from adjustments.

4 WHELAND SWIVEL SIZES

Model E-7000 — Capacity 464,300 lbs. at 100 R.P.M.
Model E-6600 — Capacity 350,000 lbs. at 100 R.P.M.
Model E-6200 — Capacity 262,000 lbs. at 100 R.P.M.
Model E-6100 — Capacity 130,000 lbs. at 100 R.P.M.

Write Dept. W-1 Bulletin No. 173 sent on request gives details, shows why more and more people are saying:

"**WHELAND** has the best swivel on the Market."

WHELAND

THE WHELAND COMPANY, CHATTANOOGA, TENN., U. S. A.
ROTARY DRILLING MACHINERY

DOMESTIC DISTRIBUTORS
Jones & Laughlin Supply Co.
Tulsa, Oklahoma
Stores and Offices in all Principal Oil Fields and Centers

EXPORT DISTRIBUTORS
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233 Broadway,
New York 7, N. Y.
Broad Street House
London E.C. 2, England

DRAW WORKS • SLUSH PUMPS • ROTARIES • SWIVELS • CROWN BLOCKS • TRAVELING BLOCKS

36—Christmas Tree Choke

This item supplements Cameron Iron Works, Inc., data as shown on pages 905-968 and 3018-3019 of Composite Catalog.

A new model Christmas tree choke, Type G, features positive or adjustable units which can be interchanged in either housing, so that a well may be washed in through the adjustable choke assembly which may then be replaced by a positive choke assembly for producing the well.

In Figure 1 is an API flanged type tee body fitted with the adjustable assembly, while Figure 2 presents the positive bean with cage nipple assembled in a screw type tee body.

Another feature of the Type G chokes is that their design eliminates the need for a bean wrench. The bean retainer in the positive type and in the adjustable type fits snugly over the bean so that it is automatically retrieved when the retainer is backed out of the choke body.

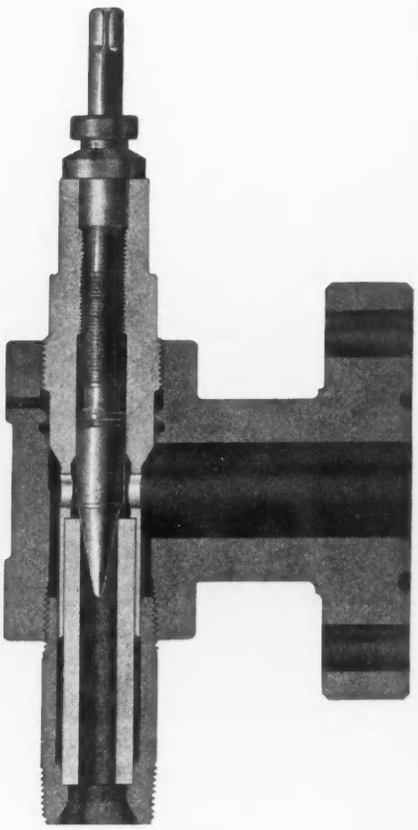


FIGURE 1

A pressure relief port is provided so that trapped pressure may be relieved automatically as the bean retainer is backed out of the body.

All parts may be replaced at the well.

For additional information write Cameron Iron Works, Inc., Silber Road, Houston, *referring to* WORLD OIL *item* 36.

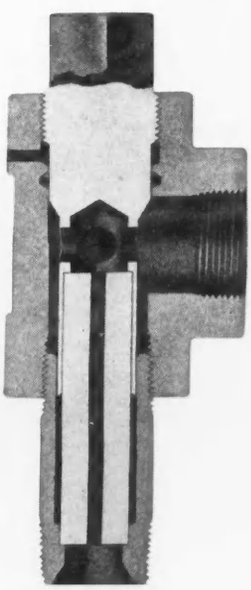


FIGURE 2

Bottom Water is a drain on profits

Eagle Lead Wool

shuts out Bottom Water!

To insure an uninterrupted flow of oil from your wells, banish bottom water with economical Eagle Lead Wool. This finely stranded metallic wool, tamped around the hole, effectively seals every crack, becomes a permanent, non-corrosive plug. Packed in convenient 50-pound sacks—easy to place in special cartridge-shaped Eagle Wire Containers sized to fit all casings.

These 3 Eagle Bearing Metals meet most requirements

Eagle Dreadnaught — for extreme speed and heavy-duty conditions.

Eagle Outlasta — for medium speed and average-load conditions.

Eagle Durable— for low speed and light-duty conditions.

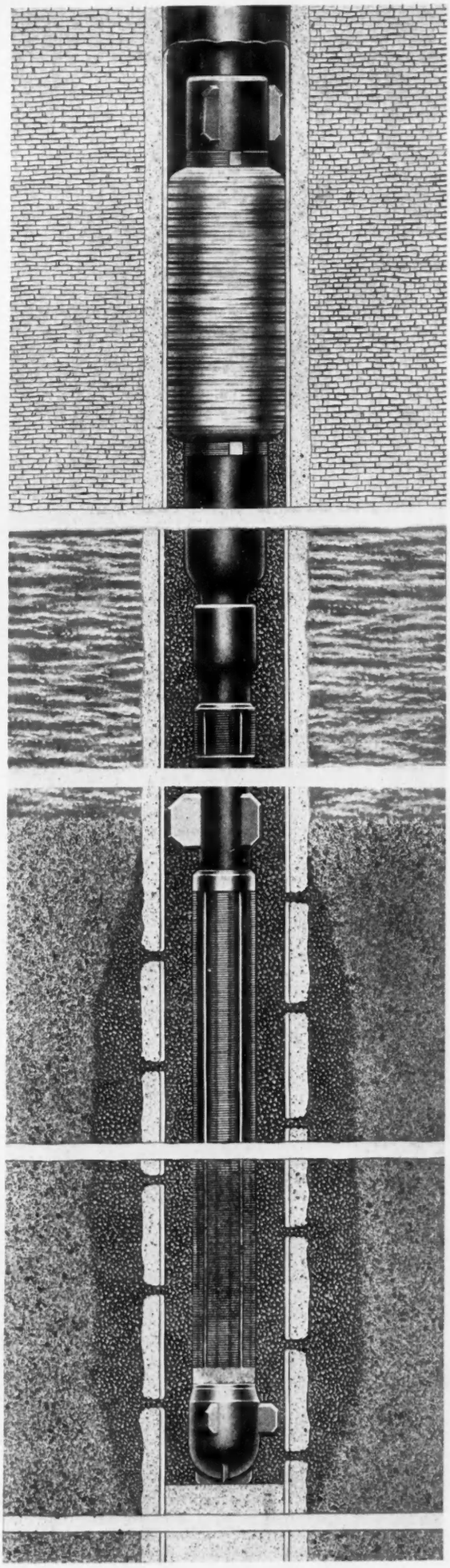
EAGLE LEAD WOOL

Seals off Bottom Water— keeps 'em flowing!

THE EAGLE-PICHER COMPANY

EAGLE Since EP 1843 PICHER

Cincinnati East St. Louis Chicago Dallas Kansas City



Yes, We Can "GRAVEL PACK" WELLS THAT HAVE Perforated Casing

☆

Gravel is nature's greatest filter . . . it does not deteriorate . . . its length of life is unknown. When placed down in a well it supports the formation, protects the screen, and at the same time allows rapid and free separation of the oil from the sand. With the gravel controlling the sand, it assures a longer, more constant flow of clean oil, doing away with costly shut-downs.

☆

ELIMINATES EXPENSIVE REWORKING

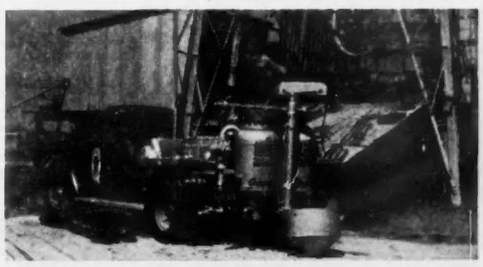
Because the Gravel Pack can neither deteriorate nor enter the screen and because it permanently supports the formation and filters the flow, you are not confronted with the frequent expense of pulling tubing to replace sanded up screen and sand cut parts and other expenses involved in reworking wells.

☆

LENGTHENS LIFE OF THE WELL

Gravel Packing controls the productive sands. It surrounds the strainer with a natural filter, coarse enough for the oil to flow through, yet fine enough to retain the oil sand in its natural state of formation. Acting as a baffle, the gravel distributes the flow through the countless channels, lowering the velocity and preventing disruption of the fine grains of sand resulting in longer life for the well and equipment.

Write for Complete Information



Write for Complete Information

THE LAYNE AND BOWLER COMPANY

EXPORT:
JEFF TUCKER
Room 1636
30 Rockefeller Plaza
New York, N. Y.

General Office & Factory
8000 Market Street
HOUSTON, TEXAS

WEST COAST:
Layne & Bowler Corp.,
900 Santa Fe Ave.,
Los Angeles, Cal.

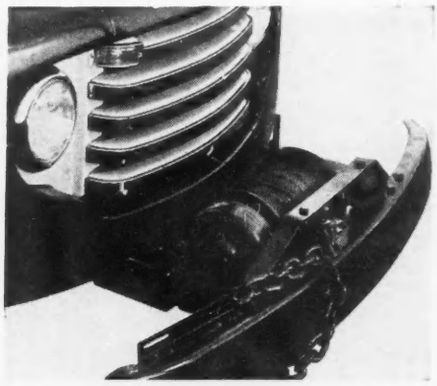
OTHER NEW AND IMPROVED *Equipment*

37—Winch

A front-end winch, which for its capacity is two-thirds lighter than a conventional winch, is the Ramsey Model 600, especially designed for front-end mounting on 1½ to three-ton trucks. The weight of the winch is 105 pounds, but the safe working capacity is 12,000 pounds and the approximate breaking point is 36,000 pounds.

The most outstanding mechanical feature is the worm and gear which makes possible the great pulling capacity for a winch of this size and weight. The design of the cable drum and gear case enables the winch to be mounted neatly on the front of a truck. Installations are easy and inexpensive and any mechanic capable of installing the power takeoff on the transmission can easily install the balance of the winch kit.

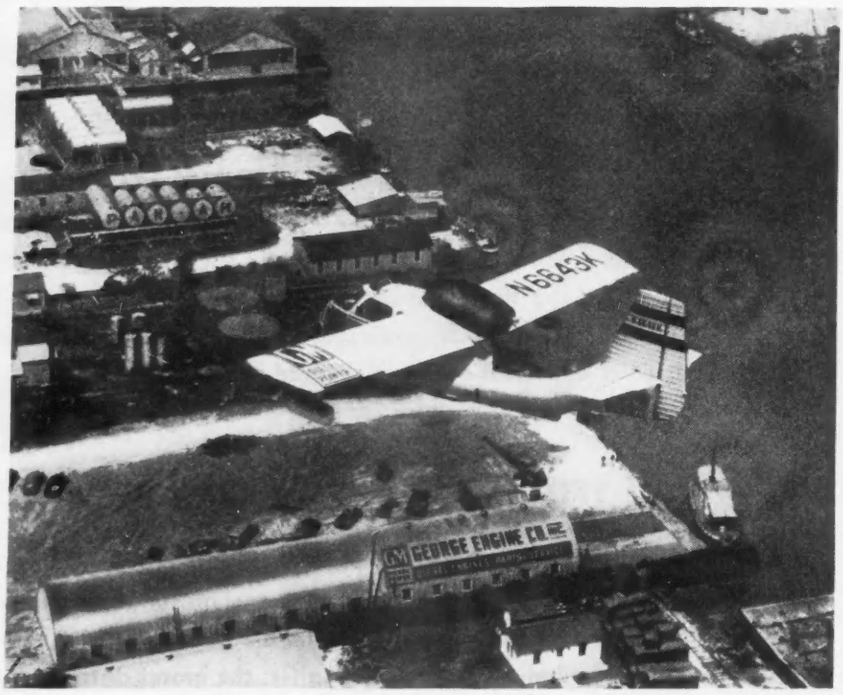
For additional information, write



Ramsey Winch Manufacturing Company, P. O. Box 3035, Tulsa, *referring to* WORLD OIL *item 37.*

Introducing our

FLYING "TROUBLE-WAGON"



● We are proud of our new Republic Seabee Seaplane, which is constantly alerted to answer your calls for service on G. M. Diesel-powered boats and rigs. Now, there's no need to suffer serious delays and shutdowns due to missing or broken parts. Give us a call, and we will literally come flying, bringing parts and mechanics to straighten out your trouble. No location is too remote or inaccessible for our flying "trouble-wagon."

● In a further effort to round out our service we have opened two new branches. The one at 630 Destrehan Avenue, on the Harvey Canal, has a canal-side dock where you can tie up. The other, in the aircraft hangar at Grande Isle, is maintained with a particular view to the convenience of operators in that vicinity.

● All of our shops are completely outfitted to service and rebuild G. M. engines. Each is fully staffed with mechanics and completely stocked with parts, and operated on a 24-hour basis.

"Round the Clock Parts and Service"

George ENGINE CO., Inc.

1111 Jefferson Highway, P. O. Box 10054
630 Destrehan Avenue (on Harvey Canal) **NEW ORLEANS, LA.**

Lake Charles Branch—718 Front Street

BRANCHES AT: — HOUMA — BERWICK — GRANDE ISLE

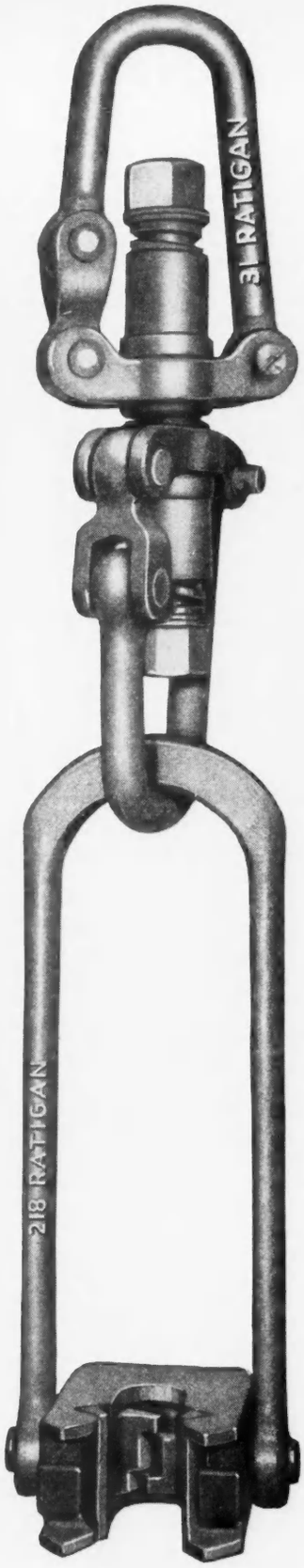
38—Low-Range Pressure Cells

Three new SR-4 Fluid Pressure Cells, extending the available ranges down to 0 to 200 pounds per square inch, one-tenth of the previous minimum range, have higher accuracy within each range. Calibration accuracy of all cells at any pressure is within plus or minus ¼ percent of full range.

Other new ranges are 0 to 500 and 0 to 1000 pounds per square inch. The three additions increase available ranges to eight: 0 to 200, 500, 1000, 2000, 5000, 10,000, 20,000 and 50,000 pounds per square inch.

The pressure cells can be used in any gas or liquid pressure system by screwing into a tapped hole opening into the system, thus giving the gas or liquid access only to a sealed tube in the cell. SR-4 resistance wire strain gauges, bonded to the outside wall of this tube, are stretched when pressure expands the tube, thus increasing their electrical resistance. This change of resistance may be measured electrically by an indicator or recorder at considerable distance, or it may be used to trip a relay or actuate a control device. The cell has no mechanical moving parts. It is especially valuable where long distance indicating is required since impulses are transmitted electrically. Only a four-volt supply is required.

For additional information write The Baldwin Locomotive Works, 940 Simpson Street, Eddystone 42, Penn., *referring to* WORLD OIL *item* 38.



Faster, Easier

OPERATING

RATIGAN

No. 218 Tubing Elevator

The Ratigan #218 is a single bail tubing elevator that can be used on either side. It was designed to fill an urgent demand for a faster, easier operating elevator for pulling tubing, especially where gin poles and Blitz rigs are used. It operates just as fast and smooth as a rod elevator.

The locking device is fast and positive, and absolutely safe, and can be operated from either the back or front of the elevator.

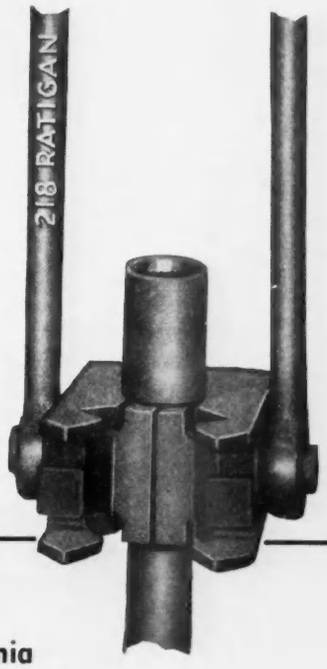
This new elevator has been tested to 200,000 pounds on an Olsen pulling machine without showing any signs of weakness. It also has been thoroughly tried out in the field under all operating conditions, and has proved very popular with the men who use it, who say it is much faster and easier to operate than the old type elevator.

It can be furnished to take either 2", 2½" or 3" tubing. When ordering, be sure to specify the size desired.

CAPACITY, 100 TONS

Weight, 118 pounds

Open position showing details of the locking device. The elevator is held by the Ratigan #31 Spring-Type Swivel "C" Link.



Ratigan #218 Tubing Elevator in closed position with tubing firmly in position.

J. P. RATIGAN, Inc.

1213 Santa Fe Avenue — Los Angeles 21, California

Ratigan Products Are Sold Through Leading Supply Stores

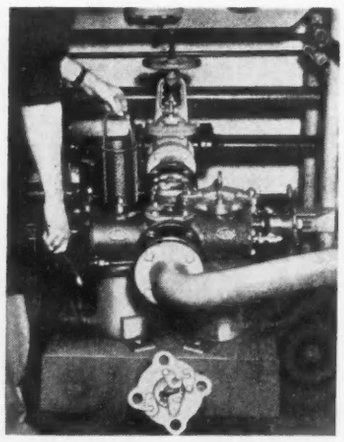
39—Duplex Strainer

A duplex strainer has been designed to handle fluids with a high solid content without the necessity of interrupting pipe line operations to clean the strainer. These units are suitable for intermittent as well as continuous flow, permitting the handling of sudden surges of solids.

Flow through the unit is diverted from one straining chamber to another by a large handwheel without the possibility of any positive shutoff. While flow passes through one straining chamber, the other may be cleaned. Covers are removable for lifting out the perforated strainer baskets.

The strainer is adapted to high open area ratio and is suitable for a wide range of pressures and temperatures. Valve seats are removable and valve stems are supported at both ends for accurate permanent alignment. A large handhole above each valve assembly permits servicing the valves without removing the strainer from the line.

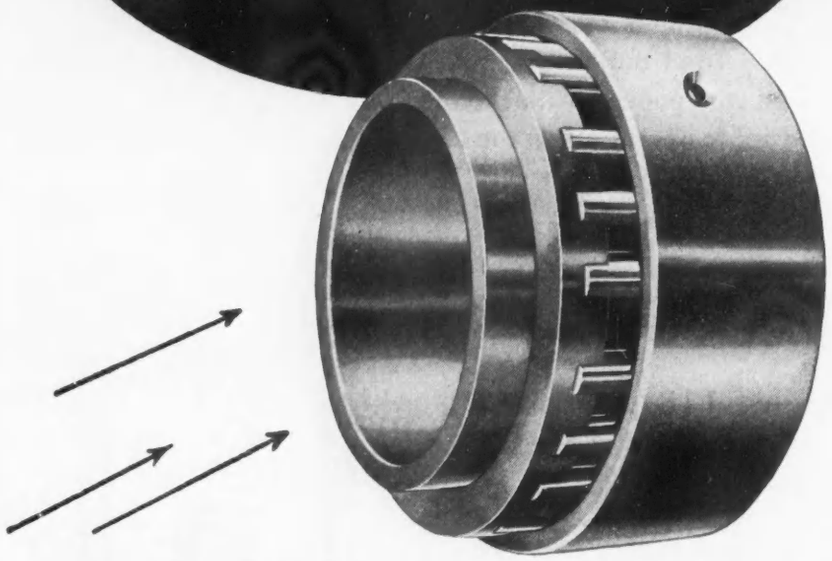
The strainer basket is set eccentrically, with respect to the basket chamber, so that the flow section is proportional to the flow needs at all points, thus minimizing pressure drop. The strainer is available in bronze, steel, semi-steel and cast iron, with strainer baskets in perforated brass, monel or other metals. Mesh or magnetic types are also available.



For additional information write Department Z-5, J. A. Zurn Manufacturing Company, Erie, Pa., *referring to* WORLD OIL *item* 39.

Gluttons for punishment

American Heavy-Duty Roller Bearings



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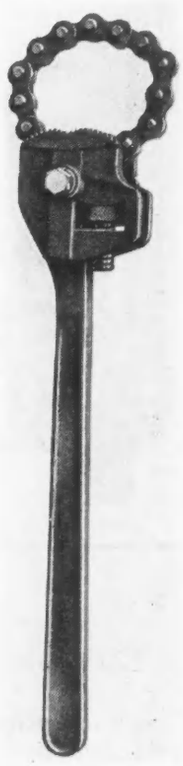
AMERICAN ROLLER BEARINGS HEAVY DUTY

AMERICAN ROLLER BEARING CO.
420 Melwood Street Pittsburgh, Pa.

Pacific Coast Office: 1718 S. Flower St., Los Angeles, Calif.

40—Chain Tong Wrench



The chain tong is instantly reversible, and in addition this ratchet action wrench has, according to its makers, 25 percent greater chain wrap than ordinary wrenches. The chain is of a type that they claim will not jam under pressure.

The makers recommend the chain tong for handling pipe in corners, coils and banks, any tight spots where other wrenches cannot operate. It is provided with an adjusting bolt for the occasional job where a tight chain may be required.

For additional information, write E-Zee Tool Manufacturing Corporation, 136 Liberty Street, New York 6, *referring to* WORLD OIL *item* 40.

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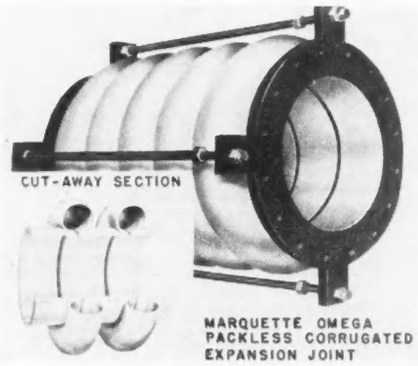
For additional information, write Marquette Coppersmithing Co., Christian and Water Streets, Philadelphia 47, Penn., *referring to* WORLD OIL *item* 41.



MARQUETTE OMEGA PACKLESS CORRUGATED EXPANSION JOINT

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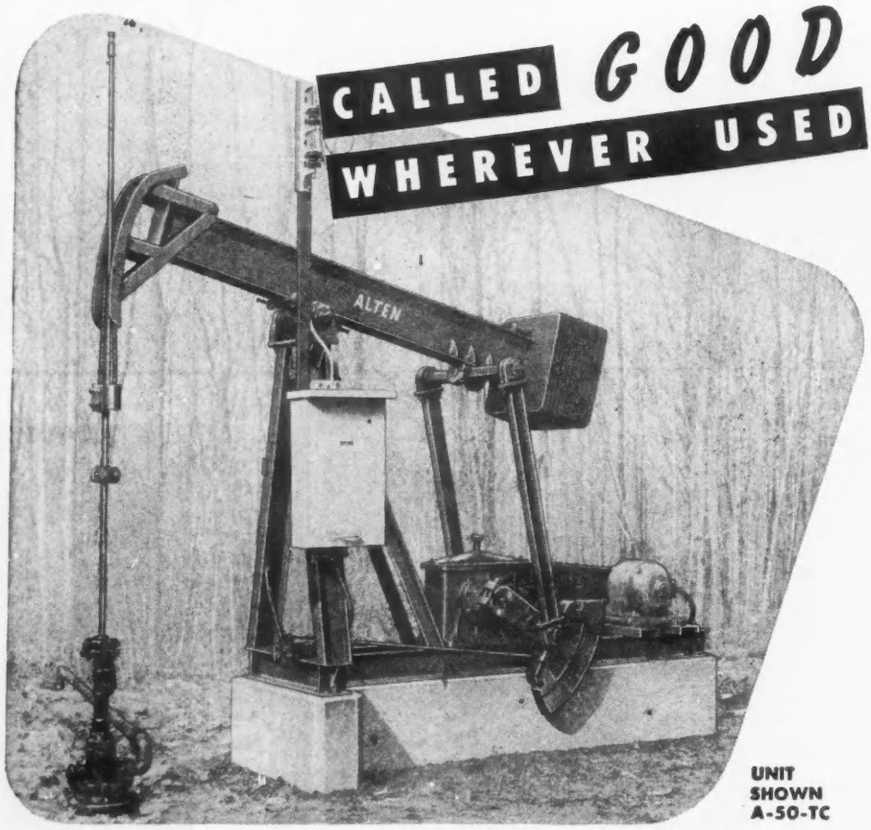

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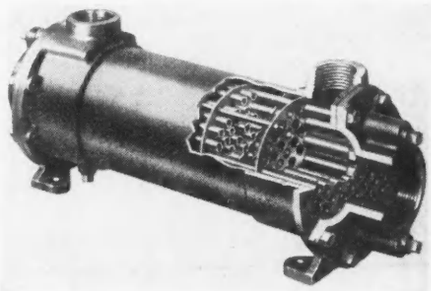
42—Heat Exchanger

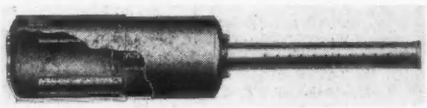
The new type Ross "BCF" heat exchanger is adaptable for diesels, gas engines, compressors, hydraulic machinery, blowers, and many other industrial applications. The exchanger is effective in heat recovery, vapor condensing and process heating applications.



For additional information write Ross Heater & Manufacturing Company, Inc., 1407 West Avenue, Buffalo, N. Y., *referring to* WORLD OIL *item* 42.

43—Exhaust Snubber

A new terminal exhaust snubber has been developed for use on all four-stroke cycle diesel and gas engines with relatively short exhaust systems in stationary and portable service and two-stroke cycle gas engine compressors operating on the Otto cycle in the petroleum field. Designated as Series SDT, these units are available in pipe sizes from five inches to 14 inches.



The new snubber combines the tail pipe with the exhaust snubber and is intended for vertical mounting at the end of the exhaust system. No additional tail pipe is required. The snubber gives effective noise control by dissipating the slug's energy before it is released to atmosphere.

High restriction is avoided by offering maximum impedance to the high-velocity exhaust slug and minimum restrictions to the normal flow of exhaust gas.

For additional information write Burgess - Manning Company, Libertyville, Ill., *referring to* WORLD OIL *item* 43.

An Open Letter

TO OUR FRIENDS AND CUSTOMERS

You may now obtain W-K-M Valves immediately from stock.

By the expansion of our manufacturing facilities to several times the former capacity, we are better than ever prepared to give you the service to which you are entitled.

The acquisition of the finest of machine tool equipment and materials, plus the knowledge gained through many years of valve manufacture, enable us to give you valves unsurpassed in performance and dependability.

During 1948 we produced fifty per cent more Production Valves than in 1947, but the demand was so great that very often we could not fill your orders promptly.

With our additional facilities, we will produce in 1949, fifty per cent more Production Valves than in 1948.

W-K-M Pipe Line Valves never interfere with the making of Production Valves, as they are manufactured in a separate division. Therefore, Pipe Line Valves never caused any delay in Production Valve shipments. We just sold more than we could produce.

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44—Triplex Pump

Data Sheet 66 pictures and describes the Aldrich inverted vertical triplex pump for petroleum, central hydraulic, and high pressure applications. It contains standard ratings, approximate dimensions, and diagrams of comparative discharge flows, describes the construction and operation of the pump, and points out its low maintenance features. An isometric drawing and various charts are used to illustrate outstanding design features.

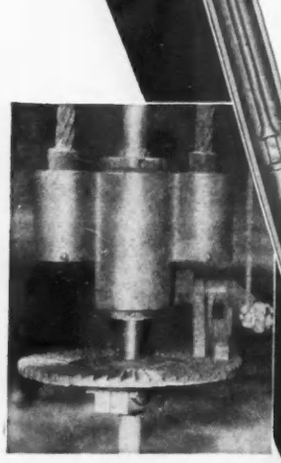
For a copy of this data sheet, write The Aldrich Pump Company, Allentown, Penn., *referring to* WORLD OIL *item* 44.

45—Carryable Generator

Homelite Corporation has issued a 12-page bulletin describing its carryable gasoline-engine-driven generators. This bulletin shows, in words and pictures, the many uses for carryable electric power.

For additional information, write Homelite Corporation, 2408 Riverdale Avenue, Port Chester, N. Y., *referring to* WORLD OIL *item* 45.

WHAT ARE YOU PAYING FOR PARAFFIN REMOVAL?



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Many major companies report Huber Scrapers have completely eliminated paraffin removal costs or reduced them to only a fraction of a cent per barrel of oil produced. Huber Scrapers, shrink-fitted to new or used sucker rods, scrape the paraffin from the tubing wall as the string rotates and reciprocates. Rods are rotated by the special Huber Rotating Rod Hanger.

Reduce or eliminate your paraffin removal costs with Huber Scrapers. Write for latest bulletin.

HUBER ROTATING ROD HANGER

This rod hanger rotates the rod string a fraction of a turn on each reciprocation. Two ratchet levers, operated by a flexible cable extending from the walking beam, engage the teeth in the turntable to turn the rod string.

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SCRAPE AS THEY ROTATE AS THEY RECIPROCATE

46—Power Slush Pump

A 16-page bulletin describes and illustrates the Ideal Type E-700 duplex power slush pump. The bulletin describes and illustrates construction details, featuring the combination of steel plates and steel castings by welding to give high strength with minimum weight, and the preloading of main and connecting rod bearings to reduce shock resulting from load reversals. It covers lubrication and gives specifications.

For a copy of this bulletin, write The National Supply Company, P. O. Box 899A, Toledo, Ohio, *referring to* WORLD OIL *item* 46.

47—Plug Valve Data

A 32-page illustrated catalog contains engineering data and descriptions of ACF lubricated plug valves. Valve sizes shown range from one-half-inch up to 16-inch designed for pressures up to 500 pounds water, oil or gas. The catalog also describes accessories for plug valves. Special information is presented on lubricants, test pressures, multi-port valves etc., of interest to the design engineer.

Copies of this catalog may be obtained by writing the American Car & Foundry Company, Valve Division, 30 Church Street, New York 8, *referring to* WORLD OIL *item* 47.

48—Arc Welders

A 36-page, three-color catalog contains illustrations, descriptions, dimensions and specifications on The Hobart Brothers Company's complete line of arc welders. Various features comprising the machines are individually illustrated and described, and helpful information is given for various welding problems. Also listed is the complete line of Hobart arc welding electrodes and accessories.

For a copy of this catalog, write The Hobart Brothers Company, Hobart Square, Troy, Ohio, *referring to* WORLD OIL *item* 48.

49—Oil Heater Catalog

Oil heating equipment is described in a new catalog. Technical data, cross-sectional diagrams and specifications as well as photographs are included on the Murdock standard vertical heater, the volume type horizontal heater, and the volume-type fire box.

For a copy of this catalog write Murdock Tank & Manufacturing Company, 3418 South Santa Fe Street, Tulsa, *referring to* WORLD OIL *item* 49.

50—Diesel Engine Booklet

Six International diesel engines, from the 39-horsepower UD-6 to the new 180-horsepower UD-24, are described and shown in a new 24-page, profusely-illustrated booklet. Specifications and dimensions of International diesel power units in easy-reference comparative tables are also included in the booklet. Copies may be obtained on request from the Industrial Power Division, International Harvester Company, 180 North Michigan Avenue, Chicago 1, Ill., *referring to* WORLD OIL *item* 50.

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PRESSURE CONTROL EQUIPMENT ...DRILLING AND FISHING TOOLS!

Stick a pin in the map of *any* oil producing country throughout the world and you have marked the location of another Shaffer product in field use. For Shaffer pressure control equipment is universally depended upon to maintain full control of pressure during all types of drilling operations, and for any casing and completion requirement. And Shaffer drilling and fishing tools are equally famous for their dependable operation under varying operating conditions.

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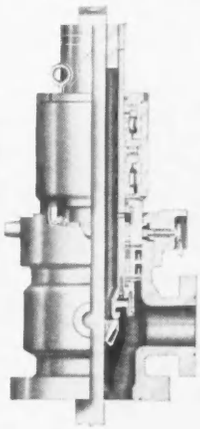
THE SHAFFER COMBINATION ROTATING BLOW-OUT PREVENTER AND STRIPPER combines in *one* tool every feature necessary for successful and simplified drilling under pressure with standard kelly and drill string equipment.



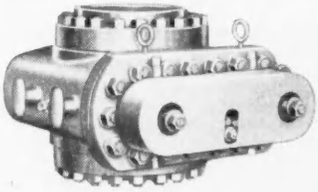
. . . it maintains a *continuous* pressure-tight seal around any shape and any diameter in the drill string (except such abnormally large diameters as the reamer or bit).

. . . it automatically expands and contracts to maintain its seal as the various diameters in the drill string are stripped through it — without manual adjustments of any kind.

. . . the kelly and stripper rubber rotate *together* — not one inside the other — thus eliminating wear on the sealing element during drilling.

. . . the stripper rubber is protected by an expandable barrier of steel latches so that the rubber cannot extrude under high pressure nor become damaged as large diameters are pulled through it.

. . . it is amazingly compact, requires no special operations or equipment and has many other advantages that make it ideal for all modern pressure control operations.



SHAFFER CELLAR CONTROL GATES are available in both *Single* and *Double* types and incorporate many unique features for safeguarding against pressure emergencies.

. . . they are unusually compact, thus saving valuable cellar space — and the Double Gate combines *two* ram compartments in one body for the maximum in space-saving compactness.

. . . they can be operated by *any* type of power — air, hydraulic, electric or steam drives — plus the added protection of full manual standby.

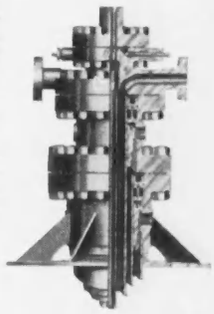
. . . their rams are opened and closed by positive mechanical drive, insuring quick, simple, foolproof operation!

. . . their rams can be quickly changed to fit various pipe sizes by simply removing one end cover, thus saving valuable time and labor when changing rams.

The above are just a few highlights of the many valuable features found in these Shaffer pressure control units. Get full details before buying any pressure control equipment!

For CASING and PRODUCTION

SHAFFER LANDING, CASING AND TUBING HEADS are used in all the major oil producing countries in the world for modern compact casing suspensions and full pressure control while producing.



They are available in many types and various packing arrangements, including types where no internal threads are used for holding the packing element in place, and also types in which all-metal packing elements are used.

For maximum compactness, Shaffer Combination Landing Base Heads combine both a landing base and head in one unit with overall height reduced to the minimum.

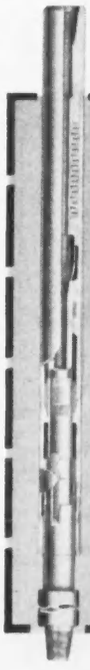
In addition, a full line of advanced Tubing Heads, Casing Heads, Multiple Zone Production Hook-Ups and other production equipment is available from Shaffer. *Be sure to contact Shaffer for your Casing, Tubing and Landing Head requirements!*

SHAFFER ADJUSTABLE FLOW BEANS embody unique advancements found nowhere else. Shaffer pioneered Adjustable Flow Beans and offers a wide range of different types for drilling, production and refinery operations. They are available with Conical, Micro, and electrically-heated Thermo Tips in both regular and hard metal designs. All popular sizes — both flanged and screwed connections!

For FISHING

Shaffer Fishing Tools are field proven and dependable for recovery operations on the deepest wells. The complete line includes Rotary Releasing Spears, Rotary Releasing Sockets, including a unique Long Pull Down Type that is ideal for fishing over unknown outside diameters . . . Expanding Pin Taps for taking a firm grip when a coupling or box is up . . . Inside Casing Cutters . . . Straight Pull Rotary Jars . . . Bumper Subs and other similar equipment.

Illustrated at right is the Shaffer Expanding Pin Tap.



NEW THE SHAFFER-WAGGENER BUMPER SAFETY JOINT for modern deep well drill string protection

No other tool gives such complete protection. It is an *automatic* Bumper Sub delivering a sharp jar-down blow by simply lowering the required weight of drill pipe upon it, whereupon the tripping device releases *automatically* to strike the blow. Blows can be struck repeatedly and continuously by simply raising and lowering the drill string. In normal drilling, the tool remains locked at all times, eliminating wear on packing and other parts.

Whenever desired, the tool can also be used as a Safety Joint to release the drill string from stuck drill collars or bits. Simply trip the tool and apply slight reverse torque as the drill string is raised, thus unlocking the Safety Joint and releasing the drill pipe for recovery. Unlike conventional Safety Joints, the Bumper Safety Joint is the strongest — not the weakest — joint in the drill string and transmits full torque in *both* forward and reverse directions when in locked position.

COMPLETE DATA *on the many items in the diversified Shaffer line are contained in the new Shaffer Catalog. Send for your free copy now!*

See pages 3843 to 3894 of your 1948 Composite Catalog for information on Shaffer products.

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BALL-TO-ANGLE SEAT
gives you a PERFECT SEAL...

...even when the pipe is not perfectly aligned!

HOT FORGED from solid, rectangular steel bars, Catawissa Pipe Unions are free from sand and blow holes. The ball-to-angle seat design plus their ability to expand and contract with the pipe give you sure fire dependability . . . a perfect seal for every application!

HOT FORGED STEEL
STAINLESS STEEL
Full ACME Threads or U. S. V-Threads in Union nuts and on female end.
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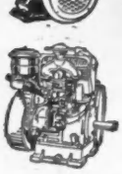
Standing ready to furnish emergency lighting at a Cheney, Kansas oil field for a large products pipe line company.



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Whether pumping oil hour after hour, summer and winter — or "standing by" ready to deliver instantly electric light and power, when the high line power fails . . . both oil men and manufacturers of equipment know that they can place complete reliance on Wisconsin power.

Every Wisconsin Engine, 2 to 30 hp., runs on Timken tapered roller bearings . . . is constructed for heavy-duty service . . . operates with a minimum of maintenance . . . is free from cooling troubles! You can't go wrong when you specify Wisconsin Heavy-Duty Air-Cooled Engines!

4-cycle, single-, two-, and four cylinder models.

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MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

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Oil field distributors for Wisconsin Engines and all types of utility units.

ASSOCIATIONS

West Coast Association Elects Taylor President

Reese H. Taylor, president of the Union Oil Company of California, was elected president of the Western Oil and Gas Association. He succeeds Ralph B. Lloyd, president of Lloyd Corporation, Ltd., who headed the association for the past seven years.

Reese H. Taylor

Officers reelected include William Reinhardt, vice president of the Union Pacific Railroad Company, first vice president; William F. Humphrey, president of Tide Water Associated Oil Company, second vice president; L. K. Whittier, vice president of Belridge Oil Company, treasurer; John M. Peirce, executive secretary, and D. S. Kilgour, secretary.

New directors are L. L. Aubert, president of Bankline Oil Company; C. E. Boone, manager of the California division of Amerada Petroleum Corporation; H. A. Eklund, vice president of British-American Oil Producing Company; R. E. Havenstrite, R. E. Havenstrite, operator; M. A. Machris, vice president of Wilshire Oil Company; Thomas W. Simmons, president of Bolsa Chica Oil Corporation; and W. W. Valentine, president of Fullerton Oil Company, all of Los Angeles; Allen A. Jergins, vice president of Jergins Oil Company, and Will J. Reid, president of Hancock Oil Company, both of Long Beach, Calif., and P. E. Lakin, executive vice president of Shell Oil Company, San Francisco. Twenty-two members of the board were reelected.

Information Committee Head Named for Rocky Mountains

Paul Hirth, division manager of the Continental Oil Company, Denver, was named chairman of the Rocky Mountain Oil Industry Information Committee. He succeeds Bud Robineau, president of The Frontier Refining Company, Denver, who has headed the program in the district since its inception early in 1947.

The Rocky Mountain district comprises Colorado, Wyoming, Utah, Montana and Idaho.

Wallace Is Elected Tulsa Purchasing Agents President

C. W. Wallace, Mid-Continent Petroleum Corporation, has been elected president of the Purchasing Agents Association of Tulsa. Other new officers: J. C. Nicholson, The Tretolite Company, first vice president; V. M. Lewis, Dowell Incorporated, second vice president; H. M. Logan, Rockwell Manufacturing Company, secretary-treasurer; F. P. Nopper, Gulf Oil Corporation, retiring president and new national director; H. M. Cosgrove, executive secretary, and E. R. Welch, assistant secretary.

Oil Compact Commission Assistant Secretary Resigns

E. G. (Ty) Dahlgren, assistant secretary of the Interstate Oil Compact Commission, has resigned to become a consultant in the Braniff Building in Oklahoma City.

E. G. Dahlgren

A geology graduate of the University of Wisconsin in 1929, Dahlgren has served in the Geological Department of the Indian Territory Illuminating Oil Company, the Oklahoma City Producers' Association, the Oil and Gas Conservation department of the Oklahoma Corporation Commission, as director of the Conservation division of the Kansas State Corporation Commission, as oil and gas valuation engineer with the Securities and Exchange Commission in Washington, and the Production division of PAW. In 1942 he joined the Interstate Oil Compact Commission as technical secretary of the Research and Coordinating committee, and subsequently was made assistant secretary in charge of technical activities.

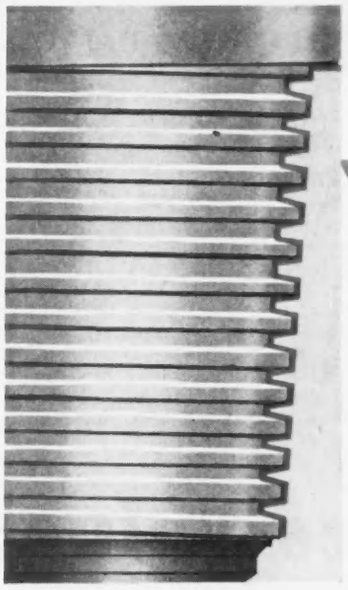
He is now serving as chairman of the Production Review committee of the Petroleum division, AIME.

Texas AIME Sections Hold Joint Meeting at Austin

Five Texas AIME sections and two student societies met at Austin, Texas, December 16-17, under the auspices of the University of Texas AIME Student Society, to discuss the engineering aspects of many oil field problems. The occasion marked the third joint meeting held by the Texas sections. The first was at Austin in 1946. Last year's meeting was at Texas A. & M. College, where the 1949 meeting will be staged.

Dr. T. S. Painter, president of the University of Texas, welcomed the group of about 130 registrants and approximately 50 students from both schools. The two-day session included 17 technical papers covering well completion, corrosion, reservoir engineering, drilling practices, and conservation. Highlighting the technical sessions was the annual student paper contest sponsored by the Gulf Coast Section of AIME and the Petroleum Division. William N. Mosley, A. & M. senior petroleum engineering student, was judged the winner for his presentation of "Marine Drilling Barges" over Charles W. Hancock, senior petroleum engineering student from the University of Texas, who discussed "A Review of Methods to Determine Connate Water."

The judges were I. W. Alcorn, 1948 chairman of the Petroleum Division, AIME; W. L. Ducker, chairman of the petroleum engineering department, Texas Technological College; and K. C. Schlater, editor, the *Petroleum Engineer*. Dr. D. M. Wiggins, president of Texas Technological College, delivered an address on "Individualism versus Security" at the banquet highlighting the meeting.



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AAODC Schedules Six Management Institutes

During February, six management institutes for executive and administrative personnel in the drilling industry will be held in eight oil centers by the American Association of Oilwell Drilling Contractors. The series is sponsored by the association and will be conducted jointly by the University of Texas and Oklahoma A. & M.

The institutes will be conducted in San Antonio, Houston, Midland, Fort Worth, Dallas and Wichita Falls, Texas, Jackson, Miss., and Shreveport, La.

Conferences and their instructors: Functions of Management, M. L. Powers, director of engineering extension, Oklahoma A. & M.; Personnel Problems in the Drilling Industry, P. J. Phillips, recent training Colonel, U. S. Army; Application of Cost Factors in Drilling, W. K. Powell, former assistant general manager of Two States Drilling Company, Dallas; Management Responsibility in Accident Prevention, J. F. Smith, former reserve corps training officer, U. S. Army; Security for the Drilling Organization, W. K. Powell; and the Legal Position of the Drilling Contractor, William Masterson, professor of oil and gas law, Southern Methodist University.

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The 20-GW swivel is used for drilling shallow and medium depth wells. The 20-GW is the smaller of the three and is used on water wells, core drilling rigs and the heavier types of Geophysical Rigs. It is also suitable for handling tubing in the shallower oil fields.

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AIME President to Assume Duties at February Meeting

Dr. Lewis Emanuel Young will formally assume his duties as president of AIME at the annual meeting of the organization in February at San Francisco. Dr. Young, a consulting mining engineer, was elected by the board of directors November 17 at New York.

Two vice presidents elected were Augustus Braun Kinzel, president, Union Carbide and Carbon Research Laboratories, New York City, and Philip Kraft, vice president, Newmont Mining Corporation, New York City.

New Directors elected were William J. Coulter, general manager, Climax Molybdenum Company, Denver; James L. Head, mining engineer, Anaconda Copper Mining Company, New York City; W. M. Peirce, chief, Research Division, New Jersey Zinc Company, Palmerton, Penn.; and George P. Swift, consulting engineer, Waltham, Mass.

Elected also were six new directors ex officios as chairmen of professional divisions: Frederick N. Rhines (chairman, Institute of Meals Division) associate professor of metallurgy, Carnegie Institute of Technology, Pittsburgh; Lloyd E. Elkins (chairman, Petroleum Division), assistant chief production engineer, Stanolind Oil and Gas Company, Tulsa; C. D. King (chairman, Iron and Steel Division), U. S. Steel Corporation, Pittsburgh; E. R. Price (chairman, Coal Division), general superintendent of mines, Inland Steel Company, Wheelwright, Ky.; Howard A. Meyerhoff (chairman, Industrial Minerals Division) professor of geology, Smith College, Northampton, Mass.; S. Joseph Swainson, (chairman, Mineral Beneficiation Division), director, Ore Dressing Department, American Cyanamid Company, Stamford, Conn.

Central Oklahoma Chapter API Elects New Officers

Ward M. Edinger, Production Engineering Laboratories, Oklahoma City, has been elected chairman of the Central Oklahoma Chapter, Production Division, API. Other new officers: W. R. Gottschall, Continental Supply Company, co-chairman; T. E. Ockerhauser, Globe Oil & Refining Company, first vice chairman; G. E. Saunders, Sohio Petroleum Company, secretary-treasurer; J. H. Field, Sohio, chairman advisory committee; J. A. Kornfeld, Sohio, chairman publicity and information committee.

Oil and Gas Law Lecture Series Is Scheduled

The fourteenth annual series of lectures on the law of oil and gas is scheduled by the South Texas College of Law at the Young Men's Christian Association, 1600 Louisiana Street, Houston.

The lectures will be held on Thursdays from February 17 to June 2.

ASSOCIATIONS

IPAA Officials Named

George F. Martin, Tulsa, and W. T. Payne, Oklahoma City, have been named vice presidents of the eastern and western districts of Oklahoma, Independent Petroleum Association of America, respectively, and will serve during 1948-49. C. E. Buchner, Tulsa, executive manager, H. B. Fell, Ardmore, executive vice president, and D. R. Snow, Tulsa, treasurer, were named ex-officio members of the executive committee for the current year.

THE OIL MAN'S CALENDAR

1949	
FEB.	
8–10	Conference on Reservoir Engineering, The University of Texas, Austin, Texas.
13–17	American Institute of Mining and Metallurgical Engineers, Annual Meeting, Fairmont Hotel, San Francisco.
MAR.	
7–10	Manufacturers Standardization Society of the Valve and Fittings Industry, Annual Meeting, Commodore Hotel, New York, N. Y.
9–11	American Petroleum Institute, Southwestern District Meeting, Galvez Hotel, Galveston, Texas.
17–18	Oklahoma Utilities Association, Annual Convention, Hotel Tulsa, Tulsa.
23–25	American Petroleum Institute, Mid-Continent District Meeting, Mayo Hotel, Tulsa.
24–25	New England Gas Association, Hotel Statler, Boston.
APRIL	
4– 5	Industrial Accident Prevention Association Convention, Royal York Hotel, Toronto, Canada.
4– 6	American Gas Association, Distribution Motor Vehicle and Corrosion Conference, Netherlands-Plaza Hotel, Cincinnati.
11–13	American Society of Lubrication Engineers, Fourth Annual Convention, Hotel Statler, New York.
11–13	National Association of Corrosion Engineers, Netherlands-Plaza Hotel, Cincinnati.
12–14	Southwestern Gas Measurement Short Course, College of Engineering, University of Oklahoma, Norman.
18–20	Midwest Power Conference (11th Annual Meeting), Hotel Sherman, Fort Worth.
20–22	Southern Gas Association, Convention Buena Vista Hotel, Biloxi.
27–29	American Petroleum Institute, Eastern District Meeting, William Penn Hotel, Pittsburgh.
MAY	
2– 4	Independent Petroleum Association of America, Mid-Year Directors Meeting, New Orleans.
9–10	American Gas Association, Natural-Gas Department, Spring Meeting French Lick Springs Hotel, French Lick, Ind.
9–11	Liquefied Petroleum Gas Association, Annual Convention and Trade Show, Palmer House, Chicago.
12–13	American Petroleum Institute, Division of Production, Pacific Coast District Meeting, Biltmore Hotel, Los Angeles.
26–27	American Petroleum Institute, Rocky Mountain District, Gladstone Hotel, Casper, Wyoming.
26–27	The Natural Gas and Petroleum Association of Canada, Annual Meeting, Hotel London, London, Ontario.

Nomads Chapter monthly meetings: **Los Angeles,** second Wednesday, Jonathan Club. B. M. Landis, Secretary. **Houston,** second Monday, Houston Club Harry E. Estes, Secretary. Telephone Charter 4-7611. **Dallas,** L. A. Little, Secretary, Telephone Justin 8-1726. **Tulsa,** third Wednesday, Hotel Tulsa. Anthony Gibbon, Secretary, Telephone 3-1844. **New York,** first Monday, Louis Sherry's, Norris Boulden, Secretary, Telephone WIckersham 2-1311, extension 260.

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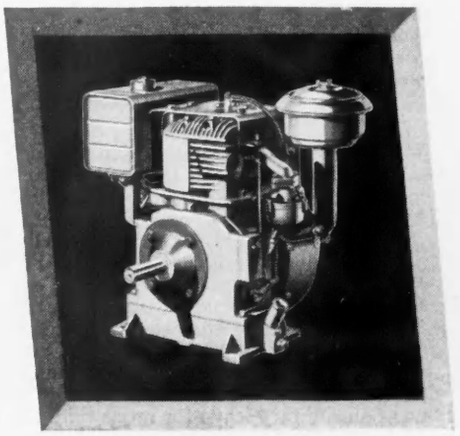

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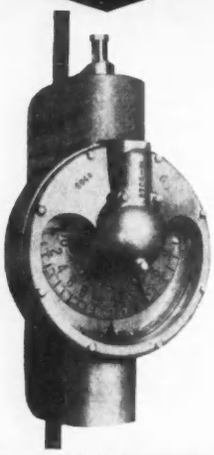

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Men in the Industry NEWS

A. Knox Tyson has been elected vice president of the American Republics Corporation. Tyson will devote his entire time to the affairs of the corporation, particularly in connection with exploration and production. His headquarters will be in the Petroleum Building, Houston. Tyson is already a director of American Republics, and was formerly a vice president of Barber Oil Corporation and for many years was associated with Continental Oil Company.

A. Knox Tyson

»

Cecil Hunt, general counsel, and **T. R. Aude,** manager, planning and economics, Stanolind Pipe Line Company, have been elected directors of the company.

»

James F. Neill, assistant district superintendent of the West Texas-New Mexico District of The Texas Company at Midland, has been promoted to assistant to division manager, West Texas Division, Producing department, at Fort Worth. Neill started with The Texas Company in 1935 as a roustabout at McCamey, Texas, and was advanced to junior petroleum engineer at Crane, Texas, in 1938. He was head roustabout at Monument, N. M., in 1941 when he went on military leave for more than four years. In 1946 he returned to Texaco as drilling foreman at Midland.

T. S. (Ted) Green has been named chief geophysicist of Sunray Oil Corporation. He was previously associated with Seismograph Service Corporation, Engineering Laboratories, Inc., and for the past three years has been with Republic Exploration Company, handling geophysical work in Southwest Texas for Sunray.

T. S. Green

John M. Schoeppel has been appointed assistant to **Louis Roark,** superintendent of the Land department. He will aid in coordinating the work of the district landmen in Louisiana, Texas, Oklahoma, Kansas, California and the Rocky Mountain States. During the past ten years he has been associated with Stephens Petroleum Company, for six years as head of their Accounting department and the last four years head of the Land department.

»

J. W. Emison has been promoted from vice president and assistant general manager of Texas Pipe Line Company to vice president and general manager.

J. T. Rynd, assistant general manager, was promoted to vice president succeeding Emison. The latter has been with the company since 1920. Rynd joined the company in 1913 and has been engaded in pipe line operations since.

SAFE DRIVER REWARDED—Elmer Hanlin, left, of Denver, Continental Oil Company tank truck driver, receives a gold watch from President L. F. McCollum in tribute to his 42-year service record without an accident and without loss of time due to illness. Hanlin, who began as a driver of a two-horse tank wagon in 1906, was honored at a dinner of more than 100 Continental officers and executives at Colorado Springs, Colorado.

MEN IN THE INDUSTRY NEWS

Guy Edwards

Leo R. Newfarmer

Guy Edwards, exploration manager for Shell Oil Company, Inc., on the Pacific Coast, retired January 1 after nearly 25 years of service. Dr. Edwards started with Shell in 1924 as a geologist in the Los Angeles office, and in 1941 was made manager of the geological department. In 1944 he was appointed to his present position of exploration manager.

Leo R. Newfarmer, formerly exploration manager in the Houston area, replaces Dr. Edwards. Newfarmer joined Shell in 1936 as an assistant geologist in San Antonio, and in 1946 was promoted to exploration manager, Houston.

»

L. D. Bartell, district geologist for Skelly Oil Company at Shreveport, has resigned to join the McAlester Fuel Company at Magnolia, Ark. He is succeeded by **M. W. Beckman.**

»

Robert E. Kepke, vice president of The British-American Oil Producing Company and the Toronto Pipe Line Company, was transferred to Toronto, Canada, as vice president of The British-American Oil Company, Ltd., in charge of the new department of Supply and Transportation.

Robert E. Kepke

In his new position Kepke will have charge of the purchasing of all crude oil and its transportation from all sources of supply. This includes purchasing in the U. S., Canada, South America and the Middle East. Kepke is a graduate in law from the University of Texas and before joining British-American in 1941, was in the Attorney General's office in that state.

»

William W. Porter II, head of Sunray Oil Corporation's West Coast land and geological department, has been placed in charge of the company's expanded Los Angeles office which will conduct the company's activities in Canada and the Near East. **John O. Maberry,** engineer-geologist, has joined Sunray's foreign operations department and will be Porter's assistant in handling the company's operations in Canada and the West Coast.

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A. F. Barrett has been advanced to manager, Rocky Mountain operations, General Petroleum Corporation. Other promotions in the Productoin department include: **C. C. Gandaubert,** superintendent, Southern division; **O. M. Jensen,** foreman, Belridge; **R. D. Townsend,** manager, Rocky Mountain Land-Contract bureau; **S. J. Tryon,** land agent, Rocky Mountain.

In the Engineering department, **C. C. Cortelyou** has been named project engineer; **C. M. Reading,** manager; **J. J. Tobin,** chief estimator; and **A. B. Westlake,** job engineer.

In other departments, **W. L. Goodman** becomes acting manager of the Transportation department; **E. S. Hochuli** becomes industrial relations manager for Northern California Marketing department operations, and **F. M. Reed** becomes master mechanic, Pipe Line department.

Seven General Petroleum employees, whose average length of service is 32 years, have retired. They are **E. J. Carnahan,** superintendent, Southern Division Production department; **V. F. Grace,** manager, Engineering department; **S. W. Hardison,** manager Rocky Mountain operations, Production department; **H. B. Hillis,** foreman, Production department; **W. J. MacArthur,** master mechanic, Pipe Line department; **Jack McGee,** superintendent of equipment, Production department; and **E. H. Vanderbilt,** maintenance foreman, Gas department.

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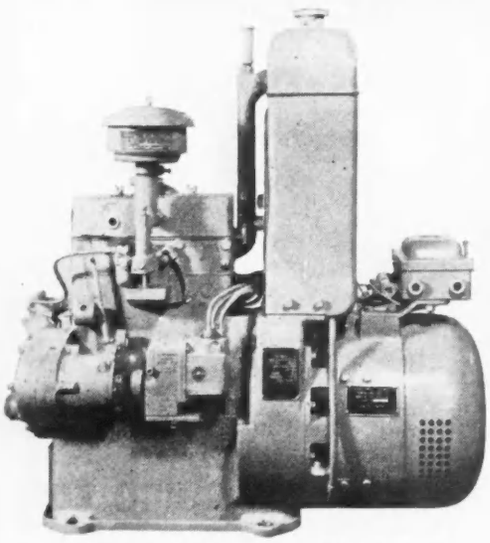

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James W. Foley has been appointed assistant to **R. Ogarrio,** vice president of The Texas Company's Domestic Producing department. He was formerly assistant division manager at Tulsa, and will now make his headquarters at New York. Foley started with the company in 1932 as a rotary rig helper, and a year later became a petroleum engineer, first at Conroe and later in the Laredo district and the Rocky Mountain division. From 1937 to 1940 he was petroleum engineer for Bahrein Petroleum Company, Ltd., on Bahrein Island, in the Persian Gulf. Returning to this country, he was named district petroleum engineer at New Iberia, La., and later superintendent of the Erath Unit operation. In 1944 he was transferred to New Orleans as superintendent of gas-gasoline operations, and in 1947 went to Houston as assistant to the manager of the Producing department. A year ago he was named assistant division manager of the Oklahoma division at Tulsa.

James W. Foley

P. E. Lakin was appointed executive vice president of Shell Oil Company. In his new capacity he will serve as Shell's senior representative on the Pacific Coast, with headquarters in San Francisco. Until his present appointment, he was vice president in charge of marketing, New York.

P. E. Lakin

Lakin began his career with Shell as a clerk in Seattle in 1915, after completing his education at the University of California. He spent two years in France with the 96th Aero Squadron during World War I, then returned to enter Shell's marketing department, where he served in several positions. In 1933 he was appointed sales manager of the Mid-Continent territory with headquarters in St. Louis, and three years later he became vice president in charge of marketing. Since 1942 his headquarters have been in New York and in 1945 he was elected to the board of directors.

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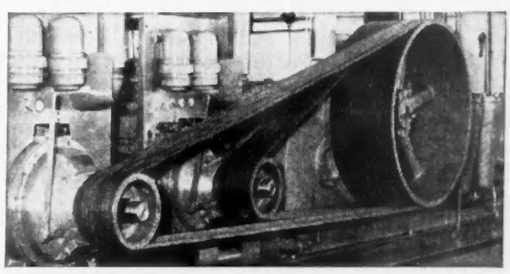

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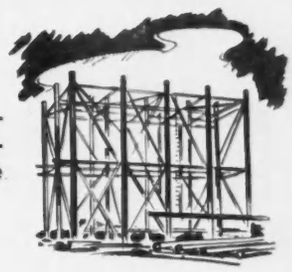

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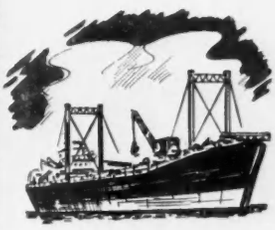

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MAIL: WESTWEGO, LA.

Transfers:

E. H. (Henry) Shaw, formerly district landman in the Permian Basin for Richfield Oil Corporation, to Midland, Texas, as an independent operator. . . . **Robert G. Trumbley,** Stillwater, Okla., to Oklahoma City to join geophysical staff of Shell Oil Company. . . . **H. C. Bowman,** formerly of Pauls Valley, Okla., to Oklahoma City as an accountant with Sohio Petroleum Company. . . . **John V. Morgan,** petroleum engineer for Stanolind Oil and Gas Company, Ellinwood, Kans., to Zenith, Kans., as field engineer. **Robert W. Banks,** field clerk at Vivian, La., to Ulysses, Kans. **Alton C. Christenson,** formerly a supervisor with a Stanolind core drill party in Florida, to Shreveport as geologist to the company's exploration office. . . . **S. B. (Bert) Fowler,** manager of the Midland, Texas, office of Wood River Oil and Refining Company, to Wichita, Kans., headquarters, where he will assume additional responsibilities. . . . **John R. Williams,** district geologist, The Texas Company, to Tyler, Texas, from Shreveport. **F. K. Moyer,** former scout at Shreveport for Texaco, to the geological department. . . . **Alfred H. Giesen,** of Hearne, Texas, division superintendent of the Products Line division of The Texas Pipe Line Company, to the Texas-New Mexico Pipe Line Company as assistant to the division manager, with headquarters at Midland. **R. F. Dorsch** succeeds Giesen at Hearne. . . . **H. Durst,** district petroleum engineer at Grand Isle, Louisiana division, Humble Oil & Refining Company, to assistant superintendent in the Bayou Sale district. He replaced **R. H. Ussery,** who was promoted to district superintendent at Grand Isle. **V. O. Harris,** former Grand Isle superintendent, went to the Lovell Lake district, from where **R. K. Tracy** was transferred to Galveston Bay district. **J. S. Hacker,** district civil engineer in charge of construction of additions to East Texas gasoline plants, to the Pickton gasoline plant construction district. **J. L. Lamberson,** petroleum engineer, Gulf Coast division office, to Sugarland district as district petroleum engineer. **McIver Hay,** rotary driller at Grand Isle, promoted to tool pusher in the Bayou Sale district . . . **George W. Hoffman,** petroleum engineer for Continental Oil Company, to Glenrock, Wyo., from Golden, Colo. **H. S. Sole,** production foreman for The Ohio Oil Company, to Eureka, Kans., from Pauls Valley, Okla. . . . **Leroy V. Hester,** to Oklahoma City from Ulysses, Kans., as petroleum engineer for Stanolind Oil and Gas Company. . . . **Z. E. Woods,** petroleum engineer for Phillips Petroleum Company, to Phillips, Texas, from Bartlesville, Okla. . . . **Harvey Cash** of Houston, promoted to assistant to division manager, Oklahoma division, Producing department, The Texas Company, and transferred to Tulsa. A petroleum engineer with South Texas division since January 1, 1948, Cash joined Texaco 15 years ago.

⁂

E. J. Yocum, Stanolind Oil & Gas Company superintendent at South Jennings, La., has been transferred to the Hastings Plant at Alvin, Texas, succeeding **C. W. Ward,** transferred to the Elk Basin plant at Powell, Wyo. **H. W. Jones,** plant foreman at the Superior plant, Vivian, La., is to be superintendent at South Jennings, and **V. E. O'Donnel,** foreman at Woodsboro, Texas, has been promoted to superintendent of Stanolind's Luby plant at Bishop, Texas.

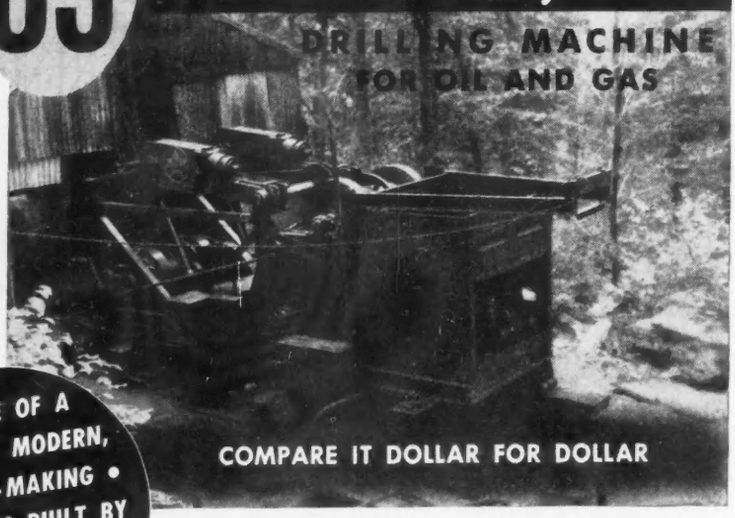
⁂

Niles B. Winter has been appointed division manager of the West Texas and New Mexico activities of The Atlantic Refining Company, with the division office located in the McClintic Building, Midland. **W. M. Ford** will be in charge of land and leasing activities, **T. C. Frick** of drilling and producing operations, and **R. T. Cox** of geological and geophysical exploration.

Correction

The December WORLD OIL reported that Stanolind Oil and Gas Company had appointed a district geologist at Midland, Texas. This is incorrect. Ed L. Reed continues as Midland district geologist for Stanolind.

THE No. 83 SPEED STAR..
THE All-Purpose DRILLING MACHINE FOR OIL AND GAS



...ONE OF A SERIES OF MODERN, • PROFIT-MAKING • DRILL RIGS BUILT BY A COMPANY 60 YEARS IN BUSINESS

This versatile all-steel rig drills top-to-bottom wells to 2500-3000 feet, tails in after rotaries, cleans out and plugs wells to 3000-4000 feet. Its two speeds forward and one-speed reverse on all reels, together with plenty of power, defy the toughest jobs. Star's exclusive balanced design and rugged construction mean dependable, economical service and long life. Many operating advantages combine with ease of moving and quick rig-up to give low cost performance and increased profits.

★

SOME No. 83 FEATURES:

1. Two speeds forward and reverse for all reels.
2. Double brakes on all reels.
3. Large capacity, full-width bull reel.
4. Fast, powerful, full-width sand reel for efficient bailing.
5. Powerful casing reel, free-running, with built-in friction clutch.
6. Powerful 6-cylinder engine.
7. Dependable V-belt drive.
8. Double-crank drive spudder balances drilling load.
9. 60' telescoping mast.
10. 44 anti-friction bearings.

MOUNTINGS: full-trailer, semi-trailer or skid.

"If It's a Speed Star, It's a Fast, Proven Money-Maker"

THE STAR DRILLING MACHINE COMPANY
475 WASHINGTON STREET • AKRON 11, OHIO
Drilling Machines and Tools Since 1889

MEN IN THE INDUSTRY NEWS

C. A. Perlitz, Jr.

Ira H. Cram

Ira H. Cram, formerly manager of exploration for The Pure Oil Company, has been appointed vice president of exploration for Continental Oil Company. Cram is a former president of the American Association of Petroleum Geologists and had been associated with Pure since 1931.

Charles A. Perlitz, Jr., Houston, vice president and director of Continental Oil Company, has been appointed vice president and general manager of the company's operations in both the Houston and Fort Worth regions. Perlitz will supervise all Continental operations in both the Gulf Coast and Fort Worth areas, which include Texas, southeast New Mexico, Louisiana, Mississippi, and southern Arkansas. Perlitz joined Continental as general attorney at Houston in 1946. **P. C. Lauinger,** publisher of the *Oil and Gas Journal,* was named to the board of directors.

H. B. Hurley, Fort Worth region production manager, has been named assistant general manager of both the Houston and Fort Worth regions. **H. L. Johnston,** who has been assistant region manager at Fort Worth, will become regional manager, succeeding Hurley at Fort Worth. **G. T. Pearson,** formerly general production superintendent, Los Angeles, has been appointed assistant regional manager, Fort Worth, succeeding Johnston.

J. W. Liddell, Continental Company's Eastern sales manager, New York, has been promoted to the new position of general manager of all company operations in the Eastern region, with headquarters in New York.

M. H. Shanahan, formerly assistant manager of the Production department, Ponca City, Okla., has been appointed to the new position of senior consultant to the department. **Glenn C. Clark,** formerly chief geologist, has been named to the new position of senior staff geologist. **J. A. Culbertson,** formerly assistant manager of the geophysical department, succeeds Clark as chief geologist. **S. K. Clark,** formerly chairman of the exploration committee, has been promoted to coordinator of exploration activities.

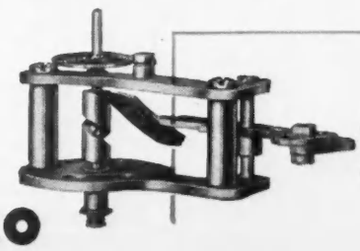
W. C. MacMillan, vice president in charge of production for Continental, has been appointed to the new position of vice president and administrative assistant to **L. F. McCollum,** president.

Here's a chemical gage for any pressure to 1600 p. s. i. and also for vacuum or compound ranges, and temperatures to 300° F.

● **An accurate pressure gage for use where chemicals or viscous liquids either corrode or clog a Bourdon tube.**

The diaphragm is "TEFLON" which resists practically all corrosive chemicals. The diaphragm chamber is supplied of any metal most suitable for the service.

Write for complete information about the new Helicoid Chemical Gage.



Only Helicoid Pressure Gages have the Helicoid Movement

ACCO

TRADE MARK

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

George C. Probst, 89, died December 13 at Tulsa. A native of Olean, Ind., he had resided in Tulsa since 1907 and his first oil venture was with the Doris Oil Company, which operated in the Bird Creek area of northeastern Oklahoma. At the time of his death he had holdings in the Garvin County, or "Golden Trend" area of Oklahoma.

»

Walter B. Fulton, retired chief engineer of Interstate Oil Pipe Line Company, died at Shreveport December 12. Fulton served as chief engineer of Interstate from 1945 until his retirement in July, 1948, and had been a veteran of 30 years service with affiliates of Standard Oil Company (N. J.).

DEATHS

F. C. Van Norman, 89, pioneer Oklahoma oil man, died December 31 at Tulsa. He was a native of Pennsylvania and operated in oil fields from Pennsylvania through Ohio to Oklahoma. During the International Petroleum Exposition of 1940 he was cited as "one of the industry's pioneers."

»

Bryce Gillespie, 64, assistant treasurer and assistant comptroller of General Petroleum Corporation, died December 17 at Glendale, Calif., after a cerebral hemorrhage. A native of Grangemouth, Scotland, he emigrated to California in 1912 and joined General Petroleum as a materials clerk on construction work at Wilmington. In 1913 he was transferred to Taft, where he handled tank car transportation. He became manager of the Accounting department in 1925 and assistant comptroller in 1930. He retained the latter post when he also became assistant treasurer in 1938.

»

Solomon R. Mealy, 71, Oklahoma oil man and senior member of Mealy-Wolfe Drilling Company, Tulsa, died December 26 after suffering a heart attack while at the wheel of his car. In 1913 Mealy organized the Rogers County Drilling Company, which was reorganized in 1916 as the Commercial Drilling Company, with Mealy as president. In 1941, **William W. Wolfe,** who was an associate, joined the firm and the name was changed to Mealy-Wolfe Drilling Company. Mealy served as president of the Oklahoma-Kansas district of drilling contractors during the period of the National Recovery Act.

»

Charles L. Reed, 72, retired Gulf Oil Corporation scout, died January 2 at Muskogee, Okla. Reed was a native of Pennsylvania and after serving in the Spanish-American War he went to Indian Territory in 1900 to establish an Associated Press office in that government center for the Five Civilized Tribes. He joined the Gulf scouting department in 1915, retiring in 1942, at which time he moved from Tulsa to Muskogee.

»

T. G. Madgwick, internationally known geologist, died at Ottawa December 14. He was associated with the Department of Mines and Resources of the Canadian government, and reported extensively on the oil areas of Western Canada. Madgwick had been professor of petroleum engineering at Birmingham University, England. He was best known for his work in Bahrein for the Eastern and General Syndicate, Ltd., of London, which secured the oil concession over that area.

»

John A. Wolfe, 74, died December 15 in Tulsa. He was known throughout the petroleum industry as a top production man and an expert on stripper well problems. In 1905 he went to work for the old Prairie Oil and Gas Company at Caney, Kans. When Prairie was absorbed by the Sinclair interests in 1932 he remained with the new company and when he retired two years ago he was chief of the northern production district for Sinclair.

»

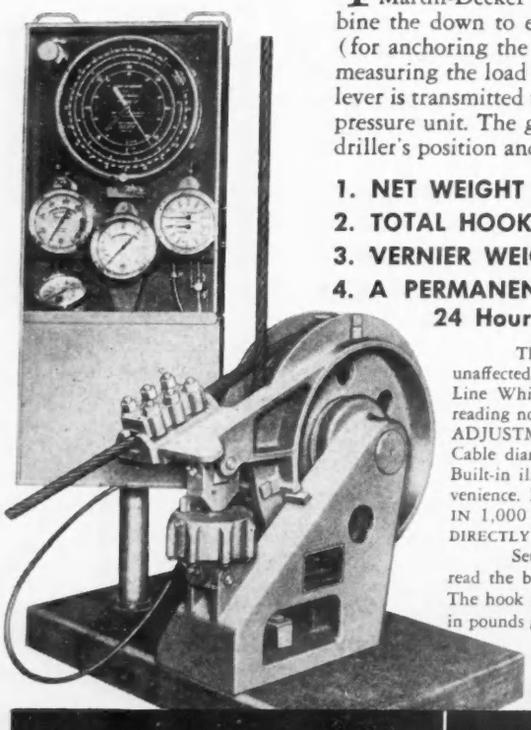
Eldon M. Eckhart, 52, executive vice president of J. M. Huber Corporation, New York, died November 28 at Amarillo, Texas. He was in charge of Huber's carbon black and oil and gas operations with headquarters at Borger, Texas.

In 1926 he joined Huber as superintendent of its Breckenridge, Texas, carbon black plant. Later he was transferred to Swartz, La., as superintendent of its plant there. In 1936 he went to Borger as assistant to the general manager and in 1938 he became vice president in charge of the Borger operation. In 1946 he was named executive vice president of the company.

Rely on this NEW combination

FOR
Accurate, Sensitive, Convenient
DRILLING CONTROL
MARTIN-DECKER
Type "D"
WEIGHT INDICATOR

AND
Simple, Safe, Efficient
WIRE LINE ANCHORING
National IDEAL
Type "D"
WIRE LINE ANCHOR



THE IDEAL Type "D" Wire Line Anchor and the Martin-Decker Type "D" Weight Indicator combine the down to earth principles of (1) the wheel (for anchoring the wire line) and (2) the lever for measuring the load on the wire line. The force of the lever is transmitted to the gauge through the hydraulic pressure unit. The gauge, of course, is installed at the driller's position and gives him:

1. **NET WEIGHT ON BIT** } **Directly In Pounds**
2. **TOTAL HOOK LOAD** }
3. **VERNIER WEIGHT INDICATOR**
4. **A PERMANENT INKED RECORD Of Each 24 Hours Operation**

The Type "D" Weight Indicator is positively unaffected by atmospheric temperature changes. Dead Line Whip can neither affect the Weight Indicator reading nor damage the instrument.—REQUIRES NO ADJUSTMENT For Number Of Lines Strung or Cable diameter. *No Gadgets or Shims To Get Lost.* Built-in illumination provides greater safety and convenience. Furnishes precise Weight-On-Bit DIRECTLY IN 1,000 LBS. and also hook load and derrick load DIRECTLY IN POUNDS.

Set the NET-WEIGHT-ON-BIT Dial on zero and read the bit weight directly in thousands of pounds. The hook load and derrick load are also read directly in pounds giving THE WHOLE WEIGHT STORY.

Type "E" Wire Line Anchors Available for 1⅜" and 1½" Wire Lines.

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EQUIPMENT AND SERVICE SUPPLIERS' NOTES

Casper Division Sales Manager Appointed by National Supply

W. T. Cushing, Jr., has been appointed sales manager of a new division sales department organized at Casper by The National Supply Company.

W. T. Cushing, Jr.

Cushing has been Northwestern division engineer for the company at Casper since 1947.

New members of the staff at Casper are R. D. Stottlemyer, division engineer, formerly of the plant products division in Houston; and K. L. Thompson, who is being transferred from the company's purchasing department in Toledo.

Dissolution of Fluor-Lewis Announced by J. S. Fluor

J. S. (Si) Fluor, Jr., has announced the dissolution of the Fluor-Lewis Company, effective immediately. Fluor, associated for many years in the management and ownership of the Fluor Corporation, severed his connections there some two years ago and with Lewis established a company to represent E. B. Badger & Sons, engineers and contractors to the oil industry.

In announcing the dissolution of the Fluor-Lewis Company, no immediate plans were given by Fluor.

Clark Names Richard Jenkins To Technical Service Office

Richard Jenkins has been appointed to the Technical Service department of the Los Angeles office of Clark Bros. Company, Inc. In 1942, Jenkins entered Yale College on a scholarship. He joined the U. S. Army in 1942, spending the first six months of his service in the Army Specialized Training Program for mechanical engineers. For the next three years he saw active service with the Seventh Army in the European theater.

In 1946, Jenkins returned to Yale to continue studies in the Yale Sheffield School of Engineering, graduating in 1948, a member of the Torch Senior Honor Society. He joined Clark Bros. in 1948 and went to the Los Angeles office after research in the plant at Olean, N. Y.

Booth to Head Brown and Root Public Relations Department

Brown Booth, public director with Tennessee Gas Transmission Company for 3½ years, has resigned to take charge of public relations and advertising for Brown & Root, Inc., Houston. Before joining T-G-T, Booth was managing editor of the Austin (Texas) *Statesman*, and prior to that was editor of the McAllen *Daily Press*. Booth is a 1935 graduate of the University of Texas Department of Journalism.

Brown Booth

He has been succeeded at T-G-T by Conrad Collier, formerly publicity manager for the Houston Chamber of Commerce. During World War II Collier was in the Army Air Force, stationed in the Aleutians, and before the war was with the Houston *Chronicle*. He is a native of Louisiana and attended Louisiana State University.

Oil Well Supply Company Appoints Fred Link General Works Manager

Fred E. Link has been appointed general works manager for Oil Well Supply Company, U. S. Steel subsidiary. Link, who for the past year has served as assistant to Fred F. Murray, president, in charge of the company's manufacturing department, will continue as the chief company official in charge of manufacturing activities, including industrial relations, industrial engineering and production. He is at company headquarters in Dallas.

Fred E. Link

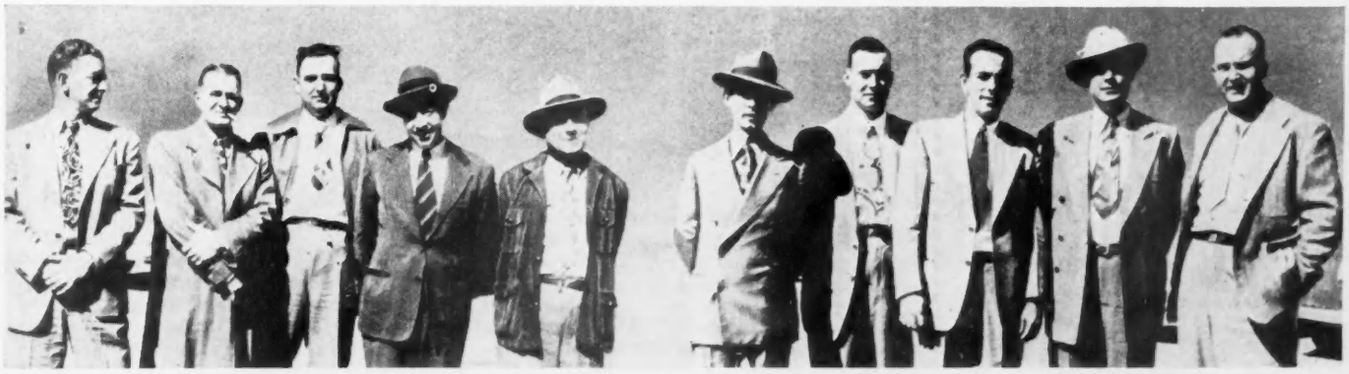
Joining Oilwell in January, 1946, Link served as assistant to the vice president, handling special industrial engineering assignments. He became assistant to the president on January 1, 1948.

Vice President and Secretary Named by Henry H. Paris Firm

Directors of Henry H. Paris, Distributor, Inc., elected A. R. Ryan executive vice president and treasurer and L. E. Proctor, secretary. In addition to the new members, the officers of the company include Henry H. Paris, president, and A. Urban Paris, vice president.

Palmer Joins Mud Control Lab

Floyd E. Palmer, formerly with Baroid Sales Division of the National Lead Company as Gulf Coast manager, has resigned and is now associated with R. J. Carlson and Robert Johnston in Mud Control Laboratories at Oklahoma City.



PATTERSON-BALLAGH SALES PLANNED—South Texas and Louisiana field sales and service representatievs of the Mid-Continent Division of Patterson-Ballagh met at Lake Charles, La., to plan sales strategy for oil field specialties in the southern area for 1949. Left to right are F. H. Byers, Robert Kimball, W. B. Gardner, J. M. Newton, Sam Drago, T. M. Smith, Jr., Ralph Snowden, A. G. Colgin, Jr., W. W. Simpson and Jack Magoffin, division manager.

Hessman SAND PUMPS

Clean Wells Faster

● POSITIVE SUCTION
Rubber cup sleeve provides positive suction with maximum lifting power.

● BETTER PICK-UP
Of larger pieces with wide opening 3-piece curved flap.

● ADJUSTABLE RELIEF VALVE
Minimizes hazards from embedding.

● PROVEN DEPENDABILITY

Lengths up to 35'
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•

SPECIALIZING in MODERN SECONDARY RECOVERY

ON IDECO SALES FORCE—Tom Alexander and Merwin Vollmer have been added to the South American sales force of the International Derrick and Equipment Company. They will headquarter at the company's new office in Caracas, Venezuela, and will accompany Mel Cooper, head technical factory representative, on his various trips in Venezuela. The addition of Alexander and Vollmer will place Ideco representatives at all key Lation American locations. Carey B. O'Conner represents the Ideco line in Brazil and Adrian D. Holland in Argentina. Left to right: Vollmer, Cooper, Alexander.

Orbit Valve Company Announces Changes in Sales Personnel

Orbit Valve Company announce the following shifts in sales personnel: G. W. (Jerry) Lowe, former North Texas representative residing at Wichita Falls, has been transferred to the Gulf Coast and will work out of the Houston branch office with R. G. (Bob) Cole. Cole has been Orbit's Houston representative for seven years. Lowe has been replaced by Jack Judd, who was formerly with Hughes Tool Company at Winfield, Kansas.

L. E. (Ed) Wallace, who has been Orbit's Eastern representative with headquarters at Newark, Ohio, for three years, has been transferred to Southwest Texas with headquarters at Corpus Christi. Wallace has been replaced in the Eastern Territory by Clyde H. Chronister, who will headquarter at Newark, Ohio. Claude Brown, who has been Orbit's Kansas representative for the past year with headquarters at Great Bend, has had his territory expanded to include the Texas Panhandle area.

No changes are anticipated for Orbit's Oklahoma representative, Jack H. Hancock of Oklahoma City, or for Dell Taylor, Orbit's West Texas representative of Midland, Texas. H. C. (Buz) Sawyer will continue to make Tulsa his headquarters for work in Dallas, Fort Worth, Oklahoma City, Tulsa, Ponca City, Bartlesville, Kansas City and Omaha.

Indian Drilling Mud's Facilities Are Expanded

The Indian Drilling Mud Company, Inc., now established in its new general office building at Britton, Okla., has opened warehouses at Kermit, Bowie and Odessa, Texas, and Eunice, N. M. Other warehouses are operated at Medicine Lodge, Lake City and Garden City, Kas.; Chico and Gainesville, Texas; Shreveport; and Britton, Maysville, Lindsay, Duncan, Seminole, Davenport, Perry, Ringwood and Elk City, Okla.

The company, owned solely by R. M. Ross and W. L. Potter, handled the mud service on the world's deepest hole, 17,823 feet, on the Weller lease at Fort Cobb, Okla., and has also handled the mud on the Vaughn No. 1 which has more open hole than any other well in the Mid-Continent area, a total depth of 12,098 feet with 1000 feet of surface pipe.

R. W. Shira Named Assistant Export Manager of Patterson-Ballagh Div.

R. W. Shira has been named assistant export manager, under Earl Rees, export manager of Patterson-Ballagh Division of Byron Jackson Company. Shira was formerly in the service division, later becoming advertising manager, in which capacity he served for over a year. He then stepped into the California sales division in the Los Angeles Basin, where he was active until his recent promotion to assistant export manager.

Tracy T. Word, Jr., Becomes Manager of Sales for WECO

Tracy T. Word, Jr., has been appointed sales manager of Well Equipment Manufacturing Corporation. He is in charge of the sales and service activities of the WECO organization, as well as supervision of the training program. Word replaces G. R. Winder, who has been appointed vice president and sales manager of Chiksan Company, parent organization of WECO.

Tracy T. Word, Jr.

Short Joins Mud Products As Equipment Division Executive

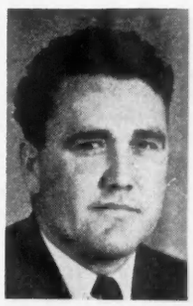
E. H. Short, Jr., has been appointed chief engineer of the equipment division of Mud Products, Inc., of Tulsa.

E. H. Short, Jr.

From 1925 until 1943, he was associated with Gulf Oil Corporation, and was chief district engineer during the Seminole boom. In 1943 he joined the *Oil & Gas Journal*. Later he was with the Frank Dyke Advertising Agency, Houston.

Kobe, Inc., Names New Assistant Manager of West Texas District

K. D. Snedeker has been promoted to assistant manager of the West Texas district of Kobe, Inc. Located at Brownfield, he has been responsible for Kobe's operations in the northern fields of West Texas. Snedeker began his oil field experience at Iraan, Texas, in the production division of Mid-Kansas Oil & Gas Company. After majoring in engineering at the University of Oklahom, he returned to the oil fields. He joined Kobe, Inc., in 1943, after ten years in the Production department of Phillips Petroleum Company, where his work included supervision of the operation of Kobe hydraulic equipment. His first Kobe, Inc., assignment was with the Technical Service section in Oklahoma City. He transferred to West Texas in 1944.



K. D. Snedeker

Baker Opens Warehouse

Baker Oil Tools, Inc., has opened a branch warehouse at Lake Charles, La., in the Corman Warehouse, Inc., building, Army Air Base. W. C. Wilson and H. E. Lyle will be transferred from Baker's Beaumont base to the new quarters.

Union Tank Opens Office

Union Tank & Supply Company has opened an office in New Orleans with W. H. Johnson, transferred from Tulsa, as manager.

Philip Carey Manufacturing Company Names Sales Promotion Manager

Frank J. Smith has been named advertising and sales promotion manager of the Philip Carey Manufacturing Company, Cincinnati. He succeeds Harold D. Bates, who was recently promoted to general merchandise manager.

Smith joined the Carey Company in January, 1948, after several years in the sales and advertising departments of Owens-Corning Fiberglas Corporation.

Here's the Mighty Hook-up for Improved Drilling!

THE 36-200 REGAN Narrow-Type Traveling Block and Forged Steel Combination Casing Hook

200-TON CAPACITY

...but only 135½" from bight of hook to top of traveling block—the shortest overall working height ever offered for such capacity!

ADVANCED DESIGN

Special adapter reduces friction, allowing the forged alloy steel combination hook to smoothly swivel at the right angle to traveling block sheaves. The traveling block is compact, narrow, streamlined for maximum safety and ease of operation.

FITS PORTABLE RIGS

Being four feet shorter, narrow and compact, this new Regan Combination is perfectly suited to portable drilling operations.

Write today for your copy of our new fully informative bulletin!

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Exclusive Export Representatives:
Hunt Export Co., 19 Rector St., New York, N. Y.
Avda Pte., R. Saenz, Pena 832, Buenos Aires, Argentina

New York Division Manager of Sales Appointed by Ideco

S. W. (Sandy) Collins, formerly West Texas district manager for Hinderliter Tool Company, has joined International Derrick and Equipment Company to become New York division sales manager.

Collins has been in oil well equipment sales for 20 years with Oil Well Supply Company, American Chain & Cable Company, and Bethlehem Supply Company. He will work with A. L. Woracek and B. V. Brown, who are now in Ideco's New York office.

Plomb Tool Company Resumes Manufacture of Finished Tools

Manufacturing of finished tools is again under way at the Los Angeles and Jamestown, N. Y., plants of the Plomb Tool Company after suspension of trademarking since November 24, 1948.

Affidavits filed by Plomb counsel in the U. S. Circuit Court of Appeals in San Francisco specified further action taken to market the company's products under the trademark "Proto" as the latest development rising out of the current trademark litigation with Fayette R. Plumb, Inc., of Philadelphia.

Resumption affects jobs of more than 700 employes in the two Plomb factories, now making tools sold throughout the nation and by export branches in South America, Europe and the Far East.

"Present demand for industry hand tools is now greater than at any time in our prewar record," stated Morris B. Pendleton, Plomb president. "Under the 'Proto' trademark the recognized quality of our tools will be backed by the largest development and sales program in our history."

Salesman Added to A. O. Smith's International Division Staff

Joseph W. Chanda has joined the International Division of A. O. Smith Corporation, and will specialize on sales of electric motors.

Joseph W. Chanda

He has traveled extensively in Latin America and has had managerial experience. He has also been on the staff of the "American Exporter," both as an account executive and foreign trade advisor.

Champion & Smith Appoint Walker Manager of Canadian Operations

L. L. (Len) Walker has been appointed manager of Canadian operations of Champions & Smith, Inc., export representatives, with headquarters in Edmonton, Alberta. Walker began his oil career with St. Helena Petroleum Company. He later drilled in South America for Shell Oil Company, pioneering in the use of the rotary system in the area, and was eventually appointed general drilling superintendent of Shell and its foreign subsidiaries.

L. L. Walker

He returned to the U. S. to supervise the drilling of Pacific Western Oil Company's first tidelands wells at Elwood. Walker served with the Barnsdall-Midway Oil Company in the Mid-Continent area as a drilling contractor, and as Gulf Coast manager of B & W, Inc. This position he resigned recently to accept the Canadian assignment with Champion & Smith.

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QUICK DELIVERY
Single X and
Double X Lathe Cut
SEAMLESS NIPPLES

Longhorn Machine Works regularly maintains large stocks of these precision manufactured nipples so that your supply store can fill your order promptly. Plastic coating protects threads from rust and handling damage insuring perfect connections.

Sizes 1/4" to 6 5/8" in standard length. Special sizes, stainless and monel furnished to requirements.

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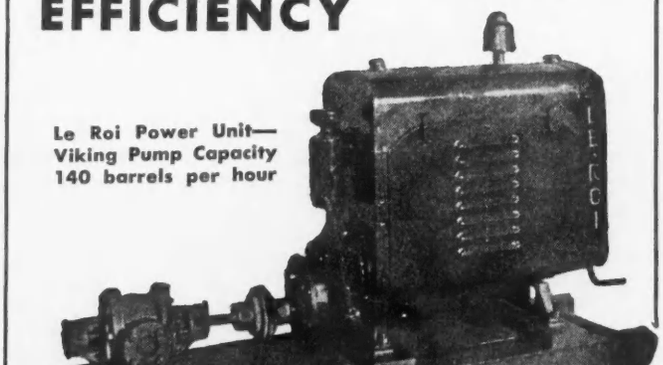
Le Roi Power Unit—
Viking Pump Capacity
140 barrels per hour



Southern Engine & Pump Company makes available to you 40 years of "KNOW HOW" in your pumping requirements.
• Complete units and replacement parts at all branches.

SOUTHERN ENGINE & PUMP COMPANY
MANUFACTURERS • MACHINERY FACTORS • CONTRACTORS
Houston - Dallas - Kilgore - San Antonio
Edinburg - Lafayette, La.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

John Gates

Foster Jordan

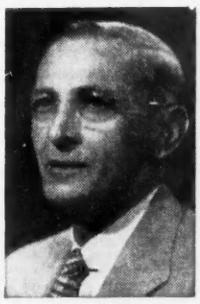
Well Equipment Manufacturing Names Two Division Managers

Well Equipment Manufacturing Corporation has named Foster Jordan and John Gates as division managers of the northern and southern divisions. Jordan will headquarter in Dallas and will supervise activities of WECO representatives in North, West, Central and East Texas, New Mexico, North Louisiana, Oklahoma, Arkansas and Kansas.

Gates, as southern division manager, will continue to headquarter in Houston and will be responsible for activities in Southwest Texas, Texas Gulf Coast, South Louisiana, Mississippi and Florida.

French Is Named Chief Engineer Of Delaney's Oil Field Division

W. Powell French has been appointed chief engineer of the Oil Field division of The Delaney Company, in charge of designing, supervision of products, development and testing. French acquired his first oil field supply experience with the E. L. Wilson Hardware Company. He was with Norvell-Wilder Supply Company from 1910 until 1918, when he became associated with Gulf in the Louisiana and North Texas warehouse division.

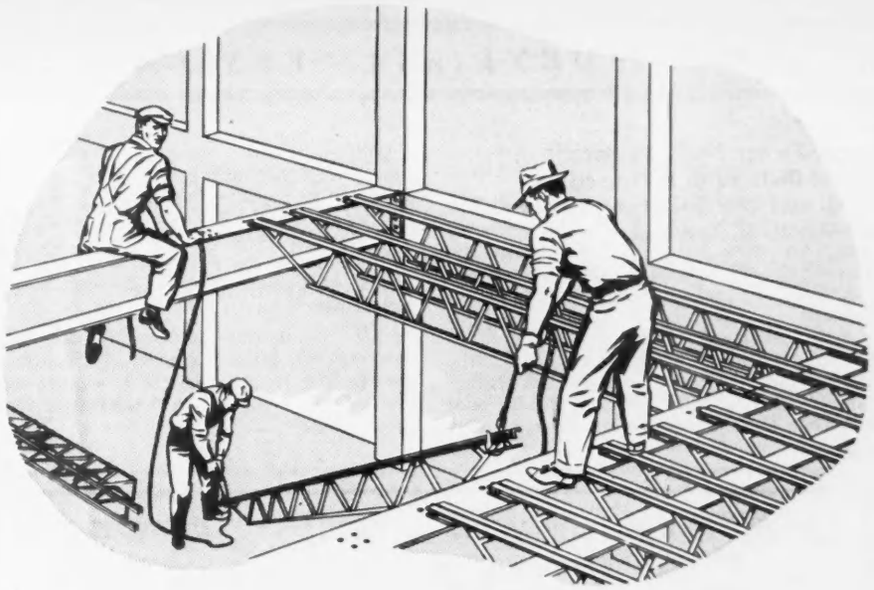


W. Powell French

In 1922, French became shipping clerk, draftsman and buyer for the Gulf Coast Machine and Supply Company of Beaumont. At that time, he became interested in engineering, and in 1927 moved to Houston to enter the pipe line business. Joining Oil Center Tool Company in 1931, he worked his way up from a job in the Testing department, where he assembled and tested Christmas trees, to the position of chief engineer and buyer.

Huber Office Expanded

The New York offices of J. M. Huber Corporation have been expanded to include the office of the director of purchases and the Finance and Accounting departments of the corporation, formerly located at the Brooklyn plant. Moving to New York are treasurer R. J. Cashion and his assistants, and director of purchases. E. M. Krech.



SHEFFIELD

STEEL JOISTS

Enable Your Architect and Builder to Effect Economies in Building from Foundation to Roof

The dead-weight of floors and roofs in any structure makes up the most of the dead-load which its foundations and supporting columns must carry.

Sheffield Steel Joists make possible floors and roofs much lighter than other types of fire-proof construction.

Not only do they contribute to more economical floors and roofs but also they effect economies in the structural members which support them.

Light in weight, Sheffield Joists are rapidly installed, requiring no falsework or shoring. Once placed, they support working-platforms from which to carry on other construction work.

Heat ducts, electric conduits, waste pipes, water and fuel lines are readily installed through the open webs of Sheffield Steel Joists instead of suspending below the bottom chord. Given ceiling heights may be obtained with less over-all building height.

Write for illustrated folder giving many other advantages.

SHEFFIELD STEEL CORPORATION
HOUSTON KANSAS CITY TULSA

SALES OFFICES: Chicago, Ill.; St. Louis, Mo.; Des Moines, Ia.; Omaha, Nebr.; Wichita, Kans.; Denver, Colo.; Oklahoma City, Okla.; Dallas, Tex.; San Antonio, Tex.; Lubbock, Tex.; New Orleans, La.; Shreveport, La.

SHEFFIELD STEEL

Carbon and Alloy Steel, Ingots, Blooms, Billets, Plates, Sheets, Merchant Bars, Steel Joists, Structural Shapes, Road Guard, Reinforcing Bars

Welded Wire Mesh, Wire Products, Wire Rods, Fence, Spring Wire, Nails, Rivets, Grinding Media, Forgings, Track Spikes, Bolt and Nut Products

Eagle-Picher Products Pacific Coast Distributor Is Named

All lead and zinc pigments and oxides manufactured by The Eagle-Picher Company are now being distributed in the Pacific Coast area through Associated Lead and Zinc Company, a corporation formed jointly by Eagle-Picher and Northwest Lead Company. Included in the Eagle-Picher products to be distributed through Associated Lead are leaded zinc oxides, lead-free zinc oxides, lead silicates, lead pigments and lead oxides.

Sidney R. Gill, director of sales, has announced the appointment of Maurice O. Barr as assistant sales manager, with offices at 2432 East Eighth Street, Los Angeles. Sales in the San Francisco area will be handled by Wallace D. Miracle, whose office will be at 725 Second Street, San Francisco.

Now being completed on a site adjacent to the Northwest Lead Company, on Harbor Island, Seattle, is a large new unit of the company to manufacture lead oxides.

Everett Carley

E. L. Alexander

Failing Licenses English Company To Manufacture Its Equipment

George E. Failing Supply Company of Enid, Okla., manufacturer of portable drilling and exploration equipment, has licensed the Mitchell Engineering Company, Ltd., of England to manufacture its line of drilling equipment. The new marketing technique is designed to reach areas which otherwise could not be served due to the dollar shortage.

E. L. Alexander, Failing's chief engineer, and Everett P. Carley, design engineer, have spent several months in England working with Mitchell engineers on the design of the equipment to be built there. The first model to be produced will be similar to the Failing 1500 Holemaster model, except that all parts have been changed to incorporate British made components and standards.

The English-built drill will have a capacity of 2500 feet with 2⅜-inch drill pipe; 1650 feet with 2⅞-inch drill pipe; and 1000 feet with 3½-inch drill pipe.

The American and British engineers cooperated in an extensive survey after which a proposal drawing was made and Alexander and Roy Avis, Mitchell engineer, toured the country inspecting the products to be used.

The engine which will be used is made by Leyland of Preston, England, and the slush pump will be manufactured by Evans of Wolverhampton.

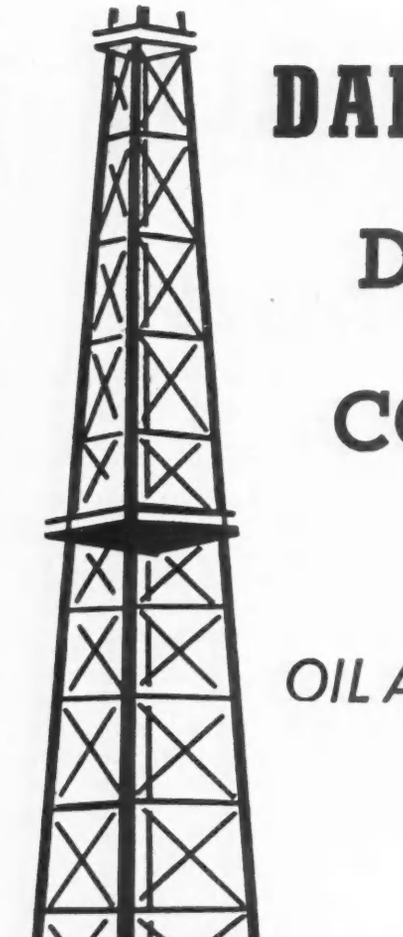
A special Failing-Mitchell Company was set up for distribution of the English-made equipment. The company will operate under a Liechtenstein charter, with Mitchell licensed to do the manufacturing at its plant at Peterborough, and the American company to control the design of the equipment. The new company will maintain a staff of field service men to check the equipment regularly and to instruct customers in the best methods of operation. Sales of the drills will be under the supervision of George P. Gregory, Jr., of New York, Failing's export manager.

Another Failing engineer is being sent to England to work with the Mitchell Company on the pilot model drill.

Rockwell District Offices Moved

Rockwell Manufacturing Company has announced that henceforth its Pittsburgh Equitable Meter and Nordstrom Valve divisions will be located at 25 Beale Street, San Francisco, and at 1102 Delano Street, Houston.

DAN L. CLARK W. M. AVERILL RUPERT COX



DAN L. CLARK DRILLING COMPANY

Drillers of OIL AND GAS WELLS

POWER AND STEAM RIGS

WILSON BUILDING
CORPUS CHRISTI, TEXAS

Telephones
Local 7746—7747 Long Distance 95

Roger Motheral Is Named to Head Gulf Publishing Eastern Sales

Roger Motheral, Central district manager at Cleveland, has been appointed vice president in charge of Eastern sales for the Gulf Publishing Company, Houston, publishers of WORLD OIL, *Petroleum Refiner* and oil industry composite catalogs. He will have offices in New York.

Roger Motheral

With Gulf since July, 1946, Motheral previously had been Eastern district manager of the *Petroleum Engineer* for ten years. For several years he worked in Texas and California oil fields, and put in two years of service in foreign fields.

Bill Westfall, now with Gulf Publishing Company in Houston, succeeds Motheral as manager of the central district of Cleveland.

G. R. Winder Is Appointed Chiksan Vice President and Sales Manager

G. R. Winder has been named vice president and sales manager of Chiksan Company, Boca, Calif. He will also be vice president and sales manager of the Chiksan Export Company.

G. R. Winder

Transferring from Well Equipment Manufacturing Corporation, Houston, he has served with the company in the same capacity for the past three years. The new assignment brings him back to Chiksan headquarters where he was formerly a member of the sales department.

Mud Products, Inc., Names Wortley Sales and Engineering Representative

Stewart W. Wortley, former assistant superintendent with Otis Pressure Control Company and safety engineer for Traders and General Casualty Company in West Texas, has been named sales and engineering representative in the West Texas area for Mud Products, Inc., of Tulsa.

Happy H. Miles will be the sales and engineering representative in the Oklahoma territory with headquarters at Mud Products main office in Tulsa.

Baker Names Branch Manager

G. W. Mitchell has been appointed manager of the new Great Bend, Kansas, branch of Baker Oil Tools, Inc., and will be assisted by Omar Kimple as warehouse manager and Ed Stoler as service engineer.

Miles was formerly associated with Anchor Petroleum Company and Southern Gas Company in the LPG equipment sales division.

C. W. Lord Advanced

Clifford W. Lord has been elected vice president of U. S. Steel Supply Company, U. S. Steel subsidiary. He will be in charge of warehouses in the Pacific Coast region.

United Centrifugal Appoints Assistant to Chief Engineer

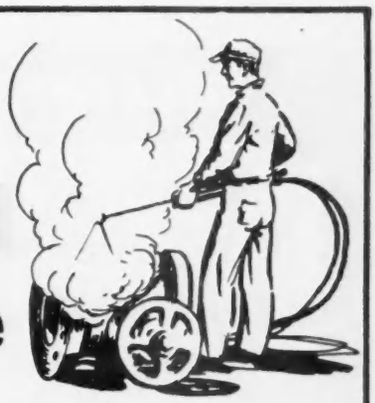
Val Lobanoff has been appointed assistant chief engineer for United Centrifugal Pumps, a division of United Iron Works, and will aid in the development of new lines of centrifugal pumps.

Lobanoff is a member of the American Society of Mechanical Engineers and the Pacific Coast Electrical Association, Inc.

How to Keep

COSTS DOWN

on Valve Maintenance



Cleaning *one* valve before overhaul won't amount to much in time or money, that's true! But multiply that one valve by thousands—at year's end your expenditure will be pretty high.

If your valve maintenance-cleaning runs into big money, we believe we can help you hold your costs way down. We believe (and many refineries will agree) that Oakite Steam-Detergent cleaning with the Oakite Solution-Discharging Steam Gun will prove infinitely superior to manual scrubbing . . . ON ALL COUNTS. It's quicker, more efficient and decidedly more economical.

Oakite Steam-Detergent cleaning is a lead-pipe cinch to install. All you need is the Oakite Gun, plus 30 lbs. steam pressure; a couple of lengths of rubber hose, and an old steel drum for your cleaning solution. You need no motor, no injector, no pump.

And the beauty of Oakite Steam-Detergent cleaning is that you can reach those hard-to-get-at places. You can use it on all kinds of equipment. You can strip paint with it.

Free 8-page folder gives all the facts on Oakite Steam-Detergent cleaning. Get yourself a copy today. No obligation.

OAKITE PRODUCTS, INC., 37 Thames St., NEW YORK 6, N. Y.

Technical Service Representatives in Principal Cities of U. S. & Canada

OAKITE 1909 1949 40th ANNIVERSARY YEAR

OAKITE

REG. U. S. PAT. OFF.

PETROLEUM SERVICE DIVISION

Hyatt Bearings Division Names Clark Township Plant Manager

A. H. Lundius has been appointed plant manager of the Clark Township, N. J., plant of the Hyatt Bearings Division, General Motors Corporation. Lundius succeeds J. C. Henny, who retired January 1.

Lundius joined Hyatt in 1935, serving at the Harrison, N. J., plant as tool designer, project engineer, supervisor of development drafting, assistant manufacturing superintendent and assistant factory manager. Lundius was assistant plant manager at Clark Township for several months before assuming his new duties.

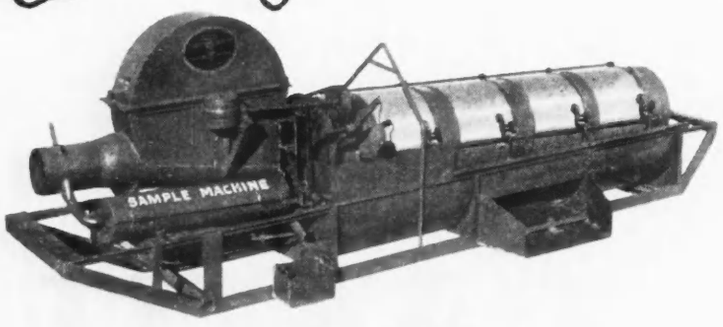
Oil Base, Inc., Drops Koebelite

George Miller, president of Oil Base, Inc., has announced that Oil Base, Inc., is no longer distributor for Koebelite diamond bits and core barrels.

"KILLER" SHALE SAYS:

I CAN LICK ANY MUDPUMP IN THE HOUSE IF THE THOMPSON SHALE SEPARATOR STAYS OUT OF THE FIGHT!

When THOMPSON SHALE SEPARATOR goes into action, you've got "Killer Shale" licked for sure. There will be less wear and tear of your drilling equipment, and your drilling mud will be thoroughly reconditioned. Self-motivating . . . perfect operation at maximum flow or idling . . . there is a model for Deep, Medium, or Shallow drilling. Accurate foot-by-foot samples of cuttings are easily obtained with the attached SAMPLE MACHINE. By-pass is standard equipment on all models.



Write Today for Free Illustrated Folder Containing Complete Data on all Thompson Separators!

THOMPSON TOOL CO.
IOWA PARK, TEXAS

KEEPS DRILLING MUD CLEAN — PROVIDES *TRUE SAMPLES* OF CUTTINGS

Prell Becomes Central Louisiana Sales Manager for A-1 Company

Furniss M. Prell, formerly of Hughes Tool Company, has become Central Louisiana division sales manager for A-1 Bit & Tool Company. His headquarters will be in Lafayette, La. Prell entered the oil business 30 years ago, first working for The Texas Company as roughneck and driller, then two years with Trinidad Leaseholds, following which he spent eight years with Shell Oil Company as drilling foreman. He was connected with Hughes Tool Company for 13 years in various capacities in the Sales department.

Furniss M. Prell

Destruction Test Is Completed On Small Hydra-Line Rig

A destruction test has been completed on the small Hydra-Line rig which was displayed at the Tulsa Oil Show. Carrying its capacity load, the rig was cycled approximately 30,000 times before failure of a crown sheave bearing caused suspension of the test.

The rig has done about 4½ billion foot pounds of work, or the equivalent of almost three years of rod and tubing work based on 52 six-day work weeks.

Examination revealed that the pistons, nestable tubes, wire lines, sheave grooves, pump and other hydraulic parts showed little signs of wear.

The XMD-975, which is the first full-size Hydra-Line rig, has been completed and is ready for field test.

Witt Leaves National Supply After 32 Years of Service

A. E. Witt, division controller and assistant secretary of National Supply Company, Torrance, Calif., retired from active duty December 31. Witt will remain with the Torrance organization in an advisory capacity. He has completed 32 years of service with National Supply. Formerly with Union Tool Company, which in 1920 became a part of National Supply, Witt was appointed office manager at Torrance in 1931, in 1944 was made division controller, and in 1947 became assistant secretary.

A. E. Witt

EQUIPMENT and SERVICE SUPPLIERS' NOTES

W. H. Tonn Joins Houston Bank's Industrial Engineering Department

Dr. W. H. Tonn, an engineer, has been added to the staff of the Second National Bank of Houston. Dr. Tonn, who holds the degrees of B.S., M.S., and Ph.D., will assist C. Cabanne Smith in the Industrial Engineering department.

Dr. W. H. Tonn

Dr. Tonn was formerly with the Rohm & Hass Company His new duties at the bank will be concerned with the gathering of data on Houston industry and the preparation of industrial surveys.

Falcon Products Sales Official Visits New York and Canada

L. A. Theisen, vice president in charge of sales, Falcon Products, Inc., manufacturers of oil field specialties — Slush Pump Liners, Pistons, Piston Rods, etc. — recently returned from New York City and Toronto where he spent two weeks making calls with the firm's export representative, Guy E. Daniels.

During his stay in New York Thiesen attended the annual meeting of the Nomads on December 4.

L. A. Theisen

Torrance Division Controller Chosen by National Supply

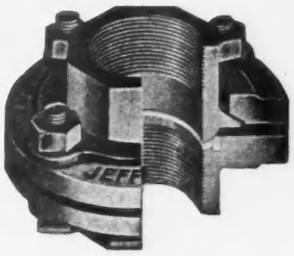
Fred W. Mill has been made division controller of The National Supply Company, Torrance, Calif. Mill has been with the company since 1917. He started with the Torrance plant as timekeeper. In 1944 he was appointed assistant division controller. In 1945 he was transferred to the executive offices in Pittsburgh as general supervisor of plant accounting, and in 1947 he became general plant controller. He takes over the duties of A. E. Witt, retired.

Fred W. Mill

U. S. Representative Named

D. F. O'Connell has been appointed representative in charge of the New York office of The Oil Well Engineering Company, Ltd. O'Connell, who has been with the company 20 years, succeeds A. R. Meyer, resigned.

Jefferson Malleable Unions



STYLE "B"

JEFFERSON Style "B" three-piece flange union is made with brass-to-iron and iron-to-iron seats. Being made of highly refined AIR FURNACE iron, it assures you of lightweight construction, perfect ball joint, and positive seating arrangement, whether or not in alignment.

★ ★ ★

HYDRAULIC PRESSURE RATING

Sizes	Test Pres.	O. W. G.	S.W.P.-550 Deg.
½" thru 4"	2000#	800#	250#
5" and 6"	1200#	500#	250#
8" and 10"	1000#	400#	250#

Malleable iron used in all JEFFERSON unions meets ASTM-4733, Grade 35018—M. T. 53000 Lbs., giving 75%-more elongation 50%-more impact value and is 30%-stronger than cupola malleable iron.

Obtainable through your jobber

Jefferson Union Company, Inc.

691 West 26th St.,
New York 1, New York

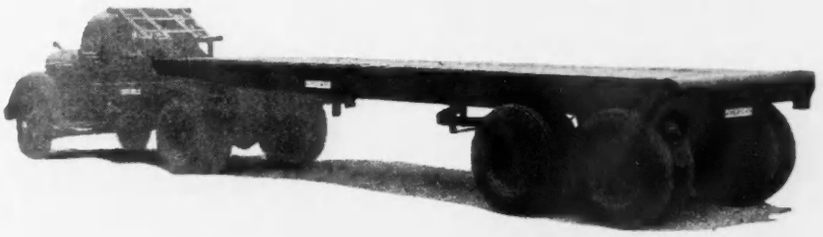
71 Gooding St.,
Lockport, New York

31 Fletcher St.,
Lexington, Mass.

On an Oil Field Trailer . . .

"A-M-E-R-I-C-A-N"

Spells DEPENDABILITY!



Behind the American nameplate is a quarter-century of experience in building a complete line of sturdy, dependable oil field trailers—both platform and pole models, of single and tandem axle design. The model SF-42-T nose-loading tandem shown here is an example of American-built platform trailers—designed, engineered and constructed to meet the most rugged hauling tests of the oil industry. We can give fast delivery on these versatile, economically-operated trailers. Let us know *your* requirements TODAY.

AMERICAN BODY and TRAILER INC.

Main Office—
OKLAHOMA CITY
1500 EXCHANGE AVE.

TULSA, OKLA.
5700 E. ADMIRAL PLACE

Branch Offices—
NORTH LITTLE ROCK, ARK.
3131 EAST BROADWAY

AMARILLO, TEXAS
740 NORTH GRAND

WORLD OIL'S Trading Post

CLASSIFIED ADS

SERVICES · PERSONNEL · USED EQUIPMENT

RATES: Regular Classified (undisplayed) set in this size type: 10 cents per word. If Box Number is to be used count an additional six words. Replies forwarded without charge. Situation Wanted: 5 cents per word. Display advertisements, set in suitably larger type with ruled border: $9.00 per column inch per insertion. Situation Wanted: $4.50 per column inch. **All classified ads payable in advance.** 10% Discount if 3 or more insertions are ordered at one time. **COPY DEADLINE:** 5th of month preceding date of issue. Send copy and checks to: Trading Post Section, World Oil, P. O. Box 2608, Houston, Texas.

FOR SALE

■ 1600 foot portable rig complete, $11,000.00. Three miles South of Corsicana. L. G. Highnote, Farm Road 709, Corsicana, Texas, Route 3.

■ For Sale: 15,000 ft. of 7" O. D. 20# used casing, one run. Earl Leech, Rockdale, Texas, phone 226.

■ WELL drilling spudders, beams, light rotaries, core drills, tools and casing. Used equipment at money saving prices. Spang and Mills new tools. Leschen lines. Everything for well drilling. Pressey & Son, Pueblo, Colo.

For Sale
USED GAS ENGINES

37 - Stationary Gas Engines—2 cycle, with Belt Wheels

Make—Bessemer - Foose

Sizes range from 22 H.P. to 80 H.P.

For inspection, correspond with or call **South Penn Natural Gas Company,** Parkersburg, West Virginia.

WE OWN
FOR IMMEDIATE DELIVERY
DIESEL GENERATOR SETS

3—G.M. Model 6-71RC, 1200 RPM, 6 cylinders, direct connected to 75 KVA Generators 3/60/127-220, complete. New 1945. Only used 100 hours. Guaranteed condition.

3—G.M. Model 8-268A, 1200 RPM, 8 cylinders, direct connected to 300 KW D.C. Generators 120/240, complete. New 1942-3.

1—G.M. Model 3-268A, 1200 RPM, 3 cylinders, direct connected to 100 KW D.C. Generators 120/240, complete. New 1942-3.

5—Superior Model GDB-8, 1200 RPM, 8 cylinders, direct connected to 100 KW D.C. Generators 120/240, complete. New 1942-3.

HEAT & POWER CO., INC.

70 Pine St., Digby 8-0373, New York 5, N. Y.

For Sale
USED PUMPS

19 - Geared, Triplex, Outside Packed PLUNGER PUMPS.

Make—National Transit - Denning - Gould. Sizes—6 x 8, 5½ x 8, 5 x 6, 7 x 10. For inspection, correspond with or call **South Penn Natural Gas Company,** Parkersburg, West Virginia.

FOR SALE

For Sale
USED COMPRESSORS

20 Ingersoll-Rand Belt Driven, Type 10 COMPRESSOR UNITS:

Two stage 5½ x 10½ - 12" stroke
Two stage 10 x 18 - 12" stroke
Single stage size range from 6 x 8 to 17 x 12

For inspection, correspond with or call **South Penn Natural Gas Company,** Parkersburg, West Virginia.

FOR SALE
LUFKIN PUMPING UNIT

Model TC-2-A-35 complete with #140 GKU Waukesha engine located in Houma, La. Used short time and in good condition. Price $3,700.00 F.O.B. Houma yard. For further particulars contact The Louisiana Land and Exploration Company, American Bank Building, New Orleans, La.

It's New... Check It!

PIPE GRINDING MACHINE designed and built to give pipe line contractors maximum service in polishing the bevel on plain end pipe in preparation for welding. The machine can be placed on pipe easily and quickly, and will clean the bevel on 24-inch pipe in 15 seconds, whereas a man with file would have to work at least 15 minutes. The grinder is constructed for durability, light weight, effectiveness and economy. Electrically driven, it may be operated from electric welding machines on the line.

The Machine was perfected, and now being manufactured by

WICHITA TOOL REPAIR CO.
of Wichita Falls, Texas
Under license from O. R. Hall, inventor.

SITUATIONS WANTED

■ CHICAGO EXECUTIVE available for part time responsibility with growing concern maintaining or contemplating Chicago headquarters. Well qualified in accounting, taxation, office and corporate procedures. Address: Box 82W, c/o World Oil, Houston, Texas.

■ Petroleum Engineering Major desires responsible work with independent or major oil company in the Houston area. Have just completed three and one-half years at University of Texas, eleven months experience with chemical supply company and three months as a Junior Engineer in research capacity with large natural gas utility corporation. Wish employment to finance last year of professional education. Affiliated with AIME and Houston Engineers Club. Address: Box 3W, c/o World Oil, Houston, Texas.

HELP WANTED

■ **Wanted:** Sales and Service Engineer. Must be familiar with drilling and production operations. Moderate salary during 60-day training period. Substantial increases periodically upon evidence of satisfactory progress. Must pass usual industrial physical examination and be willing to work in any area East of the Rocky Mountains except Wyoming and Montana. Applications from employees of contemporary firms will not be considered unless accompanied by letter from present employer indicating willingness to release without jeopardizing relations between companies. For further information write Baker Oil Tools, Inc., P. O. Box 3048, Houston 1, Texas.

WANTED: Geologist for supervisory and administrative duties exploration and drilling project Middle East. Should have some experience in seismic and surface work. Age 30 to 45. Address: Box 98W, c/o World Oil, Houston, Texas.

The Production Department of well established growing independent needs a young graduate Petroleum Engineer with one or more years field experience. Time to be devoted to drilling and production. Complete information is desired with first letter, to:

HUSKY REFINING COMPANY
Box 380 Cody, Wyoming

■ **Wanted** — Capable and experienced geologists thoroughly familiar with Mid-Continent and Gulf Coastal areas, wanted by independent producer. Give record of past employment. Liberal salary and fine opportunity for top men. Correspondence held strictly confidential. Address: Box 95W c/o World Oil, Houston, Texas.

EXPERIENCED MUD ENGINEER WANTED

California Drilling Contractor needs qualified man to assume responsibility for mud costs and control on fifteen rigs. This is an excellent opportunity with top salary for the right man. State full qualifications, experience, education, etc., in first letter. Address: Box 96W, c/o World Oil, Houston, Texas.

Sales Engineer

Experienced in gas compressing equipment. Address Manager of Sales, The J. B. Beaird Company, Inc., Shreveport, Louisiana.

NEW Books

Oil Yearbook

"The Oil and Petroleum Yearbook 1948," edited by Walter E. Skinner, is now being distributed. This is a complete and up-to-date reference work on 660 companies operating in all parts of the world, and concerned with all phases of the oil industry. Both American and foreign companies are fully dealt with.

The particulars listed for each company comprise names of directors and other officials, headquarters and zones of operation, description of business, crude production, refinery runs, details of capital, dividends and other finances.

Another section of the book contains names and addresses of 352 managers, engineers and names of the companies with which they are connected. A third section is the Buyers' Guide of Manufacturers of oil field and refinery equipment with more than 600 headings.

Walter E. Skinner, 20 Copthall Avenue, London E. C. 2, England, $4 postfree.

History of Oil Industry

"The Story of The National Supply Company" is a 48-page, 10,000-word text, liberally illustrated. An introduction to oil for the layman and an authoritative and useful work for those working within the industry, it is the story of the founding, growth and operations of a modern industrial giant. It is also the exciting and informative story of the $22 billion petroleum industry which the company serves.

"The age-old law of supply and demand," the account reads, "was responsible for the birth of the oil industry. The lamps of the civilized world were burning sperm oil early in the Nineteenth century, and the world's oceans were running out of whales. For lighting, camphene, a mixture of turpentine and alcohol, began to be used in special lamps, but that was not too popular because those lamps often exploded."

Early in the 1830's, chemists had learned to distill coal and shale to obtain kerosine, which by 1850 was in common use as an oil for lamps. It was at this point that petroleum entered the scene—through the back door. Oil, which had the annoying custom of collecting in salt wells, was being drained off and sold as a medicine and a tonic. Samuel J. Kier, of Pittsburgh, was the first to experiment with distilling this oil, producing a "light, wine-colored" distillate which he marketed as "carbon oil."

From Kier's early experience with the refining process, the monograph traces the development of the oil industry. The story is related of the first well actually drilled for oil—a modest 25-barrel-a-day strike—and the growth of an industry which started 90 years ago as a $2000 investment, and is today second only to agriculture and railroads.

The narrative tells of E. L. Drake, Uncle Billy Smith, Wolcott, Captain Lucas, Hamill, Spellacy, Lyman Stewart, Edward Double and others who are identified with the industry in the U. S.

The history of National Supply and its branches and stores throughout the world is integrated with the history of the petroleum industry. In the early days, when a well was brought in in wildcat territory and thus opened up a new field, the first to arrive were the other drillers and operators. In order for these men to go to work, they had to have supplies and equipment. The store soon became the center of all activity. Not only as a place to buy pipe and rigs to drill wells, it served also as post office, church, employment center, emergency hotel and even hospital.

Depicted in the booklet are the fabulous "Spindletop" boom, the development of the rotary drill method, the growth of the Kansas and California fields, and the new methods and equipment which are adding billions of barrels of oil to the world's reserves. The story is told of how National Supply pulled its equipment out of the Roumanian oil fields just before World War II and left empty shelves and store for Hitler to find when he marched in.

Free copies are available from The National Supply Company, Grant Building, Pittsburgh.

WANTED TO BUY

EQUIPMENT WANTED

■ Am interested in purchasing good second-hand, unit 15 rig, with either 2 or 3 motor compound. Please send description, price, and location to World Oil, Box 2608, Houston 1, Texas.

REAL ESTATE

■ FEE LAND on oil field flanks and oil prospects for sale; also plantations and ranches. W. K. Smith, Box 272, Franklin, Louisiana.

LEASES, DRILLING, ACREAGE, ETC.

■ SEE A. L. BOWLES, ADA, OKLAHOMA, FOR SHALLOW DRILLING DEALS IN OKLAHOMA.

■ We will buy producing or non-producing oil royalties. Send particulars. Standard Security Co., 115 Broadway, New York 6.

ROYALTIES IN HOT AREAS!

■ Recent strikes have focused attention on Montana's deeper oil zones and major companies are moving in fast, drilling and leasing. We buy direct in the field, sell direct to our customers. Write LANDOWNERS ROYALTIES COMPANY, Box 1225, Great Falls, Montana.

■ Prospective new shallow, high gravity oil field, N. W. Ga. Mississippian-Devonian shale and limestone exposures. Good structural indications. Drilling deals considered. Dietzen, Rt. 3, St Elmo, Tenn.

■ We desire contact with lease agent. 640 acres oil and gas lands ready for operator on very liberal terms. Address: Box 97W, c/o World Oil, Houston, Texas.

NEW CLOSING DATE for The Trading Post

Effective with the October issue, advertisements in The Trading Post section of WORLD OIL must be received by the publisher on or before the 5th of the month preceding date of issue.

NOW 3 FINE Jimmie Gray COMPOUNDS

INSURE LONGER LIFE FOR TOOL JOINT THREADS

EXCLUSIVE 500 TON SPECIAL

You can always break the joint when you use Jimmie Gray Compounds! Each one is engineered to do certain specified jobs best!

KANT-GALL TOOL JOINT COMPOUND

Both new compounds have the same dependable quality, the same money-back guarantee as the widely used Jimmie Gray 500 TON Special!

LONG-LIFE DRILL COLLAR COMPOUND

SOLD BY SUPPLY STORES EVERYWHERE

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QUICK, ACCURATE RESULTS LESS EFFORT Curtin CENTRIFUGES

No. 3420
15 c.c. machine . . .
Cranks and heads interchangeable with 100 c.c. machines.

Simple in design . . . Ruggedly built . . . Requires no special care . . . Great Ratio and throw of crank produce required speed with no strain. Curtin Centrifuges meet all A.S.T.M. Standard Method D-96 and A.P.I. Code No. 25 requirements. Fully descriptive literature upon request.

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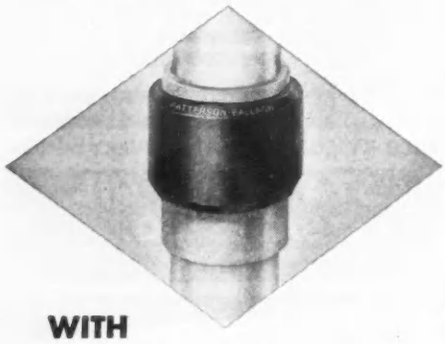
YOU CAN

Stop these Losses

AND

Save Your Casing



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Tubing collars worn by contact with casing steal the profits out of pumping. Patterson-Ballagh Plastic Tubing Protectors prevent both collar and casing wear. Oilproof, wear resistant—these protectors are securely bonded to standard size tubing collars at the factory.

See Composite Catalog for more details and *end* your tubing troubles by installing Patterson-Ballagh Plastic Tubing Protectors.

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SQUEAKS from the BULLWHEEL

Economics

We have a sneaking suspicion most chorus girls get sables the same way sables get sables.

Postal Authority

It's better that your wife find a letter you forgot to mail than one you forgot to burn.

The Woman's Way

I have a husband who is rich,
He adds much to my life,
He buys me everything I want—
But please don't tell his wife!

Can't Have Everything

A bachelor met a girl at a party and fell madly in love with her at first sight. "You're the girl of my dreams," he kept telling her during the party and on the way home. When they got to the apartment he opened the door, and there in the middle of the living room floor was a dead horse. The man stared, horrified.

"Well, for goodness sake," said the girl, "I didn't say I was neat, did I?"

Free Spender

"Never mind the expense," cried the Scotchman, "give the canary another seed."

Feminine Logic

"I'm sure my husband is unfaithful to me," she moaned, "because not one of the children looks in the least like him."

Exceptional Fellow

"My husband is one man in a hundred."

"How do you manage to keep him from knowing it?"

Darwin Was Right

This happened after World War III, when atomic bombs had killed every last human being. After three or four days, when the dust and debris had settled, a couple of monkeys came out of their cave and solemnly surveyed the desolate landscape. After several minutes, the small monkey turned to her friend and said, "Well, honey, shall we start the whole damn thing over again?"

Fashion Note

Scene in an English barroom:

Limey: "'Allo, Mary. Are you 'aving one?"

Mary: "No, it's just the cut of me coat."

Illustrated Sermon

A minister who was very fond of pure, hot horseradish always kept a bottle of it on his dining table. He offered some to a dinner guest who took a big bite. When the guest was finally able to talk, he turned reproachfully to the minister. "I've heard many men preach hell fire," he choked out, "but you're the first one I've met who serves it!"

Consistent, Anyway

"And how is the lawyer coming along?"

"Poor fellow, he's lying at death's door."

"That's grit for you. At death's door and still lying."

Good-Bye, Ry-Krisp

A girlie whose name doesn't matter
Found she was getting fatter and fatter,
But she dieted so well
That she now looks like hell,
And there isn't a place you can patter.

Athletic Type

The nice-looking young lady had just bought all the equipment necessary for a baseball game, including a baseball, a bat, a catcher's mitt, and a catcher's mask.

"Are you sure you want all these, lady?" asked the salesman.

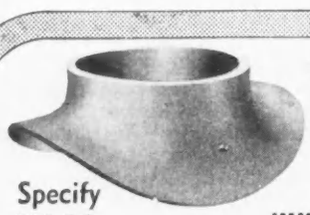
"Sure. My boss said if I'd play ball with him we'd get along fine."

Bunkhouse Life

"Me slept with Daddy last night," said the small child to the kindergarten teacher.

"I slept with Daddy last night," the teacher corrected.

"Well, then," said the child, "you must have come in after I went to sleep."



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OUTLET (OR NOZZLE) SIZES ¼" TO 16"
HEADER (OR LINE) SIZES UP TO 36"
Order Through Your Favorite Supply House

PELICAN WELL TOOL & SUPPLY CO.

P. O. Drawer 1108 Shreveport (84), La.

10 GOOD REASONS WHY OPERATORS PREFER

McCullough
GUN PERFORATOR SERVICE

1. **MEETS EVERY CONDITION.** Guns fired either electrically or mechanically: guns run on cable, sand line, drill pipe, tubing, or on piano-wire measuring line in extremely high-pressure wells.
2. **SIMULTANEOUS FIRING** under all conditions gives exact spacing of shots, perfect perforation pattern, and saves down-the-hole time.
3. **ACCURATE DEPTH MEASUREMENTS** put the shots right where you order them.
4. **MAXIMUM PENETRATION** of bullets into the formation, as proved repeatedly in competitive field tests.
5. **GUNS TO FIT EVERY CONDITION.** McCullough employs more than 30 different types and sizes of guns.
6. **ALL SIZES OF BULLETS** from $\frac{1}{8}$" dia. up to $\frac{3}{4}$" dia., to fit every possible need.
7. **BURRLESS BULLETS,** giving a completely burr-free hole, eliminating casing scraping, with *no* sacrifice of penetration.
8. **NO LOST TIME.** McCullough's simpler, lighter equipment cuts setting-up and moving-out time, speeds up every job.
9. **EXPERIENCED MEN.** With years of experience behind them, thoroughly-trained McCullough gun-perforating crews do their jobs quickly, efficiently, safely.

These Are Some of the Reasons Behind the Proven Fact That

McCullough

PUTS THE SHOTS WHERE THEY COUNT!

10 This is a section of a McCullough **90-SHOT GUN** perforating a 15-foot section with 6 holes to the foot, at one run.

McCullough TOOL COMPANY

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MISSISSIPPI: Laurel
NEW MEXICO: Hobbs
KANSAS: Ulysses
CALIFORNIA: Los Angeles, Avenal, Bakersfield, Ventura
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LOUISIANA: Houma, Lake Charles, New Iberia, Shreveport
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EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y.

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STANDCO BRAKE LINING
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DID YOU CHECK THE
Trading Post?
TURN BACK TO PAGE 262

SQUEAKS from the BULLWHEEL

Don't Mention It

Joe was sitting beside his partner who was dying. The sick man knew he was doomed and said with a sigh of repentance:

"I've a confession to make, partner. I robbed the firm of $5900. I sold the blueprints of our secret formula for $25,000. I stole the letter from your desk that got your wife a divorce, and . . ."

"Oh, don't worry, old chap," interrupted Joe. "I'm the one who poisoned you."

Busted Four-Flusher

A woman called for jury duty refused to serve because she didn't believe in capital punishment.

Trying to persuade her, the judge explained: "This is merely a case where a wife is suing her husband because she gave him $1000 to pay down on a fur coat and he lost the money in a poker game."

"I'll serve," she said, "I could be wrong about capital punishment."

Down Beat

A salesman was exhibiting a phonograph. "Just think how convenient these new records are. Here is one, from the top of which I give you Victor Herbert's 'Ah, Sweet Mystery of Life.' Then, just turn over and I give you 'Just a Little Love, a Little Kiss,' on the backside."

Direct Appointment

A wise woman makes her husband think he's head of the house when he is only chairman of the entertainment committee.

"Either the plumbers struck oil or they made the wrong connections."

Nature Study

No one pays any attention to apple skins, but, if it's a peach peeling—oh, boy!

Same Old Line

"I seem to have run out of gas," he said softly.

Her beautiful face was turned up to his, her eyes were glowing dizzily, her head swam. Why not? He was her dentist.

Capital Punishment

The penalty for bigamy is two mothers-in-law.